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Supply Corps, United States Navy

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AUTOMATED MATERIALS HANDLING SYSTEMS IN UNITED STATES NAVY WAREHOUSES

by

Charles W. Long
Lieutenant Commander
Supply Corps, United States Navy

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Centre College

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Thesis directed by

Karl E. Stromsem, Ph. D.

Professor of Business Administration

PREFACE

With the advent of the atomic age, the United States Navy is in every sense a worldwide organization. To support the ships and stations which comprise our present day Navy is a logistics task of the first magnitude.

During World War II and since then, much has been done to improve the speed and efficiency of the supply system by mechanizing or automating many of the functions. Until recently, most of these improvements were in the paperwork element of the logistics task. The use of faster means of communication and the application of electric accounting machines and electronic data processing equipments to many of the inventory management functions are representative of some of these improvements. They have contributed significantly to more effective logistics support.

Materials handling is also an important element in the total logistics task. It pervades almost every activity involved in carrying out the essential supply support for our operating forces. Within the last five years there have also been significant developments in improved methods and techniques in this area. This paper is a product of some of these developments.

The present study is not intended as a comprehensive survey of materials handling in the Navy nor of all the develop-

ments and improvements that have occurred. It is restricted to automated materials handling systems used in Navy warehouse operations. No attempt has been made to discuss the broad field of materials handling as it relates to the handling of bulk or extremely heavy items from either an equipment or methods standpoint. The main objectives have been to present the need for automation in warehouse operations, the initial research that led to the design and development of automated handling systems, the major planning considerations that preceded installation, a brief description of their major features and finally, a cost-savings appraisal of the systems.

The major sources of information for this study were the unclassified files of the Materials Handling Branch, Bureau of Supplies and Accounts and personal interviews conducted with key civilians in this office. To expand the information base, additional research was done through readings of selected literature in the materials handling field. Most of these sources of information pertained to the operating principles and general applications of mechanical handling equipments and systems. Since certain basic principles in planning and developing materials handling systems are the same, however, certain analogies have been drawn.

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CHAPTER I

INTRODUCTION

For the purpose of introduction to automated materials handling systems in the Navy, it will be helpful to briefly define the materials handling function and distinguish between the major types of systems, other than manual, that can be employed in the handling of materials.

Materials handling is the movement of materials and supplies from one place or operation to another without affecting their value or performing any productive function.[1] It includes every handling operation involved, such as picking up, elevating, conveying, transferring and setting down, during the movement of an article. Materials handling then can be conceived of as the movement of an article through space horizontally, vertically or in a combination of the two directions. Although materials handling practices vary, the basic principles remain the same.

The greatest economy in moving materials is secured by keeping handling to a minimum. When handling is required, it should be accomplished in the most efficient and economical way possible.

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[1]U. S. Department of the Navy, Storage and Materials Handling, NAVSANDA Publication 284, p. 41-1.

Within industry and the military, it is accepted that materials must be handled in one way or another as articles flow in the distribution process from producer to consumer. In recent years, there has been considerable exploration by the military and industry in developing improved materials handling techniques. Manual handling systems are progressively being superseded as industry and the military services seek to supplant them with systems which offer greater economy in movement and more efficient material flow.

This fact is borne out by statements of military and industry officials during the 1962 Joint Industry-Military Packaging and Materials Handling Symposium. Mr. Clinton B. Allen, supervisory storage specialist in the Office of the Quartermaster General, Department of the Army, in an address before the Symposium stated:

> One of our major and continuous functions in enhancing our supply responsiveness is to accelerate the movement of supplies to our customers in the most expeditious and economical manner possible. The maximum application of mechanical equipment and the development of improved methods and techniques are explored continually. Pursuant thereto, an Automated Warehouse Committee was established about 5 years ago in the Office of the Quartermaster General for the express purpose of keeping current with new developments in the art of materials handling attained by industry and other governmental agencies. As in industry we store and issue less than case lot stocks from bin storage areas at each supply depot. . . . This method of issuing stocks . . . has increased gradually in recent years and in FY 61 reached a total volume for the general depot system of 2,050,000 line items shipped from bin storage.

> The magnitude of this work load and the high degree of manual operations involved prompted a comprehensive study to determine means and ways of reducing costs. New procedures, controls, and techniques had been applied from time to time, each with some salutary effect; however, the costs continued to be unacceptable and it was concluded that a complete reappraisal of the operations should be undertaken with the view of applying mechanization.[1]

A leading industry official also noted at this Symposium:

> The decision to use an automatic handling tool instead of hand tools in securing shipping containers may appear to be inconsequential to a nation concerned with landing a man on the moon. But such relatively minor improvements in materials handling in our own company have added up to savings of over $340,000.[2]

Major advances have been made over the past 50 years in mechanizing many of the materials handling functions. More recently, there has been progress in automating certain functions. Since the two terms, mechanization and automation, are sometimes misused and confused, it is pertinent to distinguish between them. Mechanized handling systems are those systems which combine all available resources, including people, to accomplish handling, transporting and processing tasks with a minimum of manual handling. Automated handling systems accomplish these tasks without manual handling, replacing operators with control equipment having sufficient logic capability to operate the systems.[3]

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[1]National Security Industrial Association, Proceedings of the Sixth Joint Industry-Military Packaging and Materials Handling Symposium, (Washington, D. C., February 25-28, 1962), pp. 37-38.

[2]Ibid., p. 11.

[3]Ibid., p. 62.

Evolution of Modern Materials Handling Techniques

Since early history man has been struggling to find ways and means of extending and multiplying his own physical efforts in order to free his muscles from the burdens of life's tasks. One of man's earliest activities was moving various kinds of objects. The term "materials handling," taken in its literal sense, pays historical tribute to the fact that the human hand and, by extension, the human body were the first means employed in this task. Even today, the human body is the most universal type of materials handling machine. Man is able to grasp, pick up, transport, elevate, convey, transfer, and set down a wide variety of materials within the limits of his physical strength.

The movement of materials or the creation of place utility has always constituted a challenge to man's ingenuity and inventiveness. The problem of moving heavy objects was one which confronted the ancients. Two early discoveries helped make this task easier and provided an important concept for efficient materials handling. The first was by our prehistoric ancestor who found it easier to roll a burden on a log than to push it over the ground. The second was by the early Mesopotamian who adapted the wheel to the first horse-drawn chariot.[1] Unwittingly, both had made practical use of rolling contact, which in a great measure accounts for the high efficiency of the present day materials handling equipments.

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[1]Oliphant D. Haynes, Materials Handling Equipment (Philadelphia: Chilton Company, 1957), p. 3.

A review of several equipment manufacturers' advertisements published in the materials handling trade journals reveals some of the advancements that have been made in the materials handling field. A recent issue of Modern Materials Handling[1] shows a picture of a heavy duty lift truck which can pick up and elevate a load weighing six tons to a height of 30 feet and move it left or right for storing in bins or racks. It also has the capability to tow materials on the highways. Similarly, a current advertisement shows how an automatic tow-line conveyor, operated and controlled by one man, can keep a steady flow of 40,000 pounds of materials continuously moving from unloading dock to specific warehouse storage areas.[2] These are a few examples of the progress made in devising new equipments to improve materials handling efficiency.

When we measure some of our modern materials handling achievements against the unknown methods of the ancients, we cannot but marvel at many of their accomplishments also. Some of their handling feats would provide a test for the most modern of materials handling equipment.

For example, what can we say of the Druids, who were moving 10 ton stones across Southern England 1500 years before Christ? In some unknown manner, they carried these huge slabs

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[1]York Manufacturing, Inc. Advertisement. Modern Materials Handling, Vol. IXX, No. 7 (July, 1964), p. 20.

[2]Mechanical Handling Systems, Inc. Advertisement. Material Handling Engineering, Vol. IXX, No. 1 (January, 1964), p. 14.

over water and land from a quarry in Wales to the mystic circle at Stonehenge and set them erect, even though the stones were 15 feet tall. In looking at Stonehenge it might be agreed that handling its stones would present a real challenge to the modern materials handling engineer and any equipment he might select for the job.

Another remarkable engineering feat was the building of the famous pre-Inca temple high in the mountains near Cuzco, Peru. Individual stone blocks to build this temple were quarried from a valley more than 2000 feet below the temple site. The builders apparently were not familiar with the principle of the wheel. Even if they were, it is difficult to see how they could lift such huge weights to such heights, but they did.[1]

The construction of the pyramids in ancient Egypt is a widely recognized phenomenon in materials handling engineering. One writer has suggested that the Egyptians probably used the idea of load unitization--making one big load of many small ones to transport materials to the construction site.[2] It was not too many years ago that the idea of unitized loading on pallets was conceived by the United States military and thought of as a dramatic improvement in materials handling.[3] However, it is

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[1]John R. Immer, Materials Handling (New York: McGraw-Hill Book Company, Inc., 1953), pp. 14-15.

[2]National Security Industrial Association, Proceedings of the Seventh Joint Industry-Military Packaging and Materials Handling Symposium (Washington, D. C., February 10-12, 1964), p. 10.

[3]Onnie P. Lattu, "Integrated Materials Movement System," Monthly Newsletter-Magazine of the U. S. Navy Supply Corps, Vol. XXVII, No. 2 (February, 1964), p. 4.

possible the Egyptians even preceded us with the original concept.

Although many kinds of material lifting and transporting devices were used extensively prior to 1900, they were for the most part restricted to the movement of material too heavy for handling by manpower. The revolutionary idea which developed shortly after the turn of the century was that, although certain materials, because of their limited weight and size could be moved by manpower, mechanical equipment could and should be used for their movement. The rise of this concept represents the birth of modern materials handling techniques.

Importance of Efficient Materials Handling

Within recent years a number of figures have been developed to show the amount of materials handling costs involved as a part of the total production process in industry. For example, as late as 1946, after the war had apparently streamlined production, materials handling expenses in the average factory represented one-third of the total labor payroll. Today, this same cost commonly accounts for about one-third of total production costs, not labor costs alone.[1] Naturally, the percentage of materials handling costs as a part of total production cost will vary from one industry to another. Their main value is to point out the importance of the materials handling function. Understandably the importance of the function is greater in those

[1]National Security Industrial Association, Proceedings, 1964, p. 11.

industries where there is a high ratio of handling cost to the total processing cost than in those activities in which the ratio is considerably smaller.

From the standpoint of the national economy, the cost involved in the movement and handling of materials assumes gigantic proportions. Within industry, the cost of moving materials from one place to another is often more than the cost of processing itself. When the cost of transporting raw materials, partly finished assemblies and parts, and the finished product is added, the result is one of the largest single items of expense in the total economy.

From the standpoint of the individual company, materials handling can be the millstone that plunges the firm into bankruptcy or retires it to a secondary position in the competitive picture. On the other hand, efficient materials handling may be the means of launching a new business (by extending services and products at the lowered production cost thus made possible) or the sole means of continuing corporate existence in the face of restricted price levels and rising costs.

From the standpoint of labor, improved methods of materials handling offer the greatest prospects for higher wages and better working conditions. Since wages are dependent upon productivity, it is to the interest of labor to assist management in lowering production costs and increasing output. At the same time, the decrease in heavy lifting and "man handling" of materials has

removed a large part of the hazard and fatigue from many production jobs. The efficient plant is the safe plant; and efficient movement of materials is the best safeguard for the worker's welfare.[1]

A Need for Improved Materials Handling in the Navy

An essential element of national defense is the ability to apply military power where and when needed. Supply is an integral part of that ability. Within the Department of the Navy, the Bureau of Supplies and Accounts is responsible for the operation of the Navy Supply System. This system is designed to provide supply support locally and to our fleet units and overseas stations. Through the system flow stocks, in varying quantities, of more than one million different items,[2] with physical characteristics ranging from miniaturized missile parts weighing a fraction of an ounce to fire control detectors weighing 25 tons. The system is concerned with the functions of procurement, stock control, distribution and warehouse operations. This latter function, warehouse operations, includes the physical receipt, storage, issue and packing of material, all of which involve materials handling. These activities form a substantial part of

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[1]Immer, *loc. cit.*, pp. 4-6.

[2]John Henderson, "Serving Two Masters," *The Defense Supply Association Review*, Vol. LXII, No. 2 (September-October, 1962), p. 18.

the operating costs of the Navy Supply System. Also, the degree of efficiency with which these activities are performed helps determine the effectiveness of support achieved for the operating forces.

The primary function of the Bureau of Supplies and Accounts is service; in fact, the official crest of the Bureau contains the words "Service to the Fleet." To provide the type of service required of a modern, progressive fleet containing nuclear powered ships with the most modern missiles, the Bureau must be aggressive and correspondingly modern and forward thinking in its management. It must lead the field in examining and experimenting with new management techniques and rapidly adopt and put into practice those which will improve service to the fleet. Also, in keeping with the emphasis on a conservative budget during peacetime, it must operate the system with maximum economy and efficiency.

Recognizing the importance of optimum service at minimum cost, the Bureau of Supplies and Accounts made several advances in improved supply techniques during the post World War II period, especially in the area of inventory management. Methods for predicting requirements moved from manual methods and simple machines to automatic systems using high speed communications coupled with solid state digital computers. Using advance decision rules and mathematical formulae these new machines enabled the system to digest a mass of statistical data and

forecast requirements precisely; consequently, inventory investment was sharply reduced.

Additionally, the Bureau had undertaken aggressive action through cataloging, standardization and disposal programs to reduce the number of items in the supply system. Despite progress in these programs, however, the rate of scientific development was generating new items so fast that the number was increasing instead of decreasing. For example, 25 years ago, a Navy destroyer used 60 different types of vacuum tubes. As more sophisticated electronic principles were applied to navigation, fire control and underwater detection, the demand for tubes increased until today the allowance list for a destroyer calls for 4,800 separate types of tubes.[1] Thus, items entering the supply system due to scientific advances were outstripping efforts to streamline the system.

Inventory management is an important element of the Navy Supply System; however, it is valueless without effective material distribution. Without responsive material flow, there is no supply system, no effective fleet support--only static inventories. Warehouse operations is an integral part of the material distribution process. In the warehousing field, there is a genuine requirement for efficient materials handling techniques if the supply system is to respond effectively to the 100,000

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[1]E. R. Sharp, "Material Handling in Physical Distribution," Transportation and Distribution Management, Vol. II, No. 5, (May, 1962), p. 18.

receipt and issue line item transactions required daily at the Navy's supply centers and other major stock points.[1] The number of line item transactions does not tell the complete story, however, especially from the warehousing workload standpoint. In looking at the problem further, it must be borne in mind that the character of the supply system is somewhat unique. The Navy catalogs more than one and a quarter million line items. The term "line items" includes materials, parts, components, sub-assemblies, equipments, accessories and attachments. The actual workload in warehouse operations is measured, however, not by the number of line item transactions, but by the quantity of individual pieces handled. Consequently, when a supply center or depot receives and issues 5,000 line items per day, it could well mean the handling of 25,000 individual pieces.

It has been pointed out that materials handling represents a large part of the labor costs in many commercial concerns. The materials handling activities at some of the Navy's large supply centers and depots are no exception to this fact. In a survey conducted at the Naval Supply Center, Oakland, California in 1958, it was reported that only eighteen percent of the personnel were engaged in the material flow processes with over twenty-five percent being employed in the traffic function alone.[2]

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[1] Ibid., p. 19.

[2] U. S. Department of the Navy, Material Flow Process at NSC, Oakland, A report prepared by the Management Planning Division, U. S. Naval Supply Center, Oakland, California, December 19, 1958.

Thus, it is evident that the materials movement problem in Navy warehouse operations is of special importance. Any effort to achieve more efficient materials handling would obviously benefit the customer, in terms of improved service, and possibly lead to reduced handling costs. Chapter II will discuss some of the initial research and investigation the Bureau and stock points conducted in seeking improved handling methods.

CHAPTER II

WAREHOUSE AUTOMATION STUDIES

Initial Research

The increasing demands upon the Naval Supply System and the continuing need for greater economy and efficiency in its operations and techniques prompted the Bureau of Supplies and Accounts to undertake a study on the feasibility of introducing automation into warehousing operations. In February, 1957, the Bureau initiated a research project through the Bayonne, New Jersey Naval Research and Development Facility to carry out such a study.[1]

The study was to be conducted in three phases. Phase A was to determine the existence of examples of partial or complete automation and extensive mechanization in commercial and military warehousing systems. Phase B was to examine the Naval Supply System for promising applications of warehouse automation. The findings and recommendations emerging from phases A and B were to be used as a basis for determining the advisability and practicability of extending the project through phase C. Phase C was to develop, install and evaluate a pilot model of an automated

[1]U. S. Department of the Navy, Chief, Bureau of Supplies and Accounts, Letter SS3 A11/3, February 11, 1957.

materials handling system in the warehouse operations of a naval supply activity.

To carry out phase A of the project a survey team of four members was formed. A list of commercial companies and Air Force activities was compiled which could possibly furnish the information and data desired. Twenty installations were selected and visited from a list of approximately 35. The companies and military activities visited were requested to furnish information on their accomplishments in warehouse automation or advanced mechanization and the extent to which these had been incorporated into their operations.

The findings of the survey team were that none of the installations visited had a fully automated warehouse system.[1] In fact, the survey team reported it was unable to contact any person who could furnish information on such a system, either in industry or the Department of Defense. The general attitude of industry seemed to be that the high research and design costs precluded the installation of fully automated systems, and, as a result, individual companies had mechanized or automated only to the extent to which their particular requirements demanded. Much had been done to automate production facilities, but the automation of the warehousing function appeared to be of less concern to management. Most of the officials contacted agreed that full

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[1] U. S. Department of the Navy, Bureau of Supplies and Accounts, Development of Automated Warehouse Systems--Phase A--A Study of Current Commercial and Military Warehousing Systems, Project No. NT003-020, June 15, 1957, p. 2.

automation of warehousing operations was a fertile field and definitely a future possibility, but most of them felt that such a concept extended far into the future. The survey team found that little was actually being done, even on the drafting board, to indicate that industry or the military were contemplating any major moves into the area of warehouse automation.

A few of the commercial installations visited, however, had partially automated warehouse systems. Two of these appeared to offer a great deal of promise, at least from the standpoint of the Navy emulating some of their major features in any system it might develop. One was a drug wholesaler in Los Angeles and the other the central warehouse of a women's and children's wearing apparel chain in New York. Major features of their systems included electrically powered belt conveyors for in-system movement of material, automatic controls for directing order-accumulation operations, an automatic tally for detecting human errors in routing before shipments were made, and controls for sorting and accumulating outgoing shipments. Basically, through the use of associated electronic equipment the systems enabled one operator to control the entire movement involved in filling an order from the time it was "picked" from its storage place to its delivery in the packing section.

The warehouse operations of the other activities visited were mechanized to various degrees, depending upon their particular requirements. Outstanding examples of extensive mechanization were

found at all of the Air Force installations visited. The survey team reported these installations were rapidly approaching the maximum in the mechanization of warehousing operations. Very few of the materials handling operations were being accomplished manually. Generally speaking, however, mechanization of materials handling functions was restricted to standard commercially available materials handling aids, such as fork trucks, roller and skate wheel gravity conveyors, and, in some instances, powered belt conveyors.

On completion of phase A of the warehouse automation research project in June, 1957, the survey team launched phase B to determine those areas in the Navy Supply System to which automated materials handling techniques might be applied. The entire warehousing system was critically analyzed, operation by operation and element by element to ascertain the areas having the most potential.

The survey team reported that after discussion with representatives of the activities visited certain basic criteria would be prerequisites for an automated system.[1]

First, volume or rate of stock turnover should be of sufficient magnitude to warrant use of automated procedures and equipment. Because of the volume required to justify an automated installation, the team felt that only fast moving items should be initially considered for automation.

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[1]U. S. Department of the Navy, Bureau of Supplies and Accounts, Development of Automated Warehouse Systems--Phase B--An Examination of the Naval Supply System for Promising Application of Automation, Project No. NT003-020, October, 1957, p. 1.

Second, container sizes should be standardized as far as possible. The complexities of equipment design that might be required as a result of nonstandardization of container sizes might easily put an automation program into a cost prohibitive category.

Third, a standard unit of issue should be established. The team felt this was not absolutely essential; however, it would simplify automated procedures to a great degree.

After carefully analyzing the four basic operations encompassing the warehousing system of a typical naval supply activity--receiving, storage, packing and shipping--the team found that several of the elements of each operation offered good prospects for automation. The team concluded, however, that the issuing and sorting elements of the storage operation appeared to be the most suitable for automation. The commercial activities visited during phase A of the project, which had the highest degrees of automation, appeared to concentrate on these elements of warehouse operations for application of automated systems. The survey team also felt that the "picking" and "sorting" elements of the storage operation would afford the greatest potential for savings in money and manpower and therefore should be considered as initial starting points for the introduction of warehouse automation.[1]

Material such as electron tubes and shoes, which were already packaged in relatively standard containers, both as to size

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[1] Ibid., p. 7.

and shapes, appeared to conform as closely to the basic automation criteria as any other material in the supply system and were recommended as good starting points in the selection of material for a pilot installation. Other items which also appeared to be adaptable to initial automation were subsistence items in case lots, standard size forms, pamphlets, envelopes, and other office supplies.[1]

The survey team reported that it had not examined the paperwork system, such as records, requisitions and invoices associated with the physical handling of material, due primarily to the magnitude of such a study and the unavailability of time to conduct it. The team did feel, however, that before any pilot automated warehousing system was installed the paperwork system should be carefully studied and revised where necessary, to ensure its compatibility with the physical movement of material under an automated system.[2]

Finally, the survey team concluded that prior to the introduction of automation into the warehousing process at any naval supply activity consideration should be given to certain concepts which would facilitate automated procedures. Among these were: storage of materials by popularity, i.e., those items with the highest turnover rate should be stored in the most accessible locations; modification of the materials accounting system to conform

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[1]*Ibid.*, p. 5.

[2]*Ibid*, p. 6.

with an automated system; institution of single item invoices and post posting procedures; and forwarding of issue documents at predetermined time intervals during the day to permit a more efficient scheduling of material selection and issue.[1]

Additional Study and Investigation[2]

The findings presented in these preliminary warehouse automation studies were very encouraging. While it was evident that a number of changes would be required in existing warehouse procedures before any automation could be effected, continued exploration to develop some type of automated handling system appeared warranted. In this connection, the Bureau of Supplies and Accounts decided to contact selected materials handling equipment manufacturers and encourage them to visit several typical Navy warehouses for the purpose of observing operations and submitting informal proposals on those areas of materials handling that appeared to be susceptible to automation.

Several manufacturers were consulted and arrangements made for them to visit various supply installations. The Naval Supply Depots at Bayonne, New Jersey and Newport, Rhode Island and the Naval Supply Center at Oakland, California were some of the activities chosen for study and evaluation. Manufacturers'

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[1] *Ibid.*, p. 6.

[2] The information for this section was primarily obtained from the unclassified "Automated Warehouse File, Part 2," Equipment and Materials Research Division, Bureau of Supplies and Accounts.

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[1] *Ibid.*, p. 6.

[2] The information for this section was primarily obtained from the unclassified "Automated Warehouse File, Part 2," Equipment and Materials Research Division, Bureau of Supplies and Accounts.

representatives visited these activities and their preliminary proposals suggested that automation of the stock picking function would be applicable only in those areas where standardized container sizes were used.

The American Machine and Foundry Company did, however, submit a proposal for a system that could automatically pick several different container sizes. The proposed system featured a device similar to the slave manipulators used for the remote handling of radioactive materials. The manipulator, or selector arm as it was called, was to be suspended from an overhead traveling beam crane which could move over the bin areas of a warehouse. The selector arm could be positioned horizontally and vertically for access to any portion of the bin area. Mounted on the same carriage as the selector arm was to be a lightweight television camera. The entire system was to be remotely controlled by a single operator seated at a control console. Positioning of the selector arm in front of a bin area was to be entirely automatic. By means of a "glove" control and a closed circuit television screen located at the control console, the operator could identify the material to be picked and grasp it with the selector arm. The items were then to be deposited in a basket mounted on the carriage below the selector arm. From there, the baskets were to be deposited on a belt conveyor which would deliver them to packing stations.

The major limitation of this system was its inability to automatically pick the many different unpackaged bin items, such as hand tools, nuts, bolts, and similar materials. Although this and several other proposals for automating the stock picking function merited consideration, they were not economically feasible because they could be adapted to only a limited number of the items stocked without extensive revision in requisitioning procedures and modification of existing packaging specifications.

More representative of the realities of the situation in automating warehouse operations were contained in the observations, conclusions and recommendations presented by Jervis B. Webb Company after it completed an evaluation study at the Bayonne, N. J. supply depot. The company stated in its report:

> There are many parts in the 350,000 odd items in storage that would be impractical to automate due to the variety of shapes, sizes and types.
>
> The necessity of having the parts stored in bins with narrow aisles makes the introduction of conveyors between bins a very difficult problem. It would be impractical to insist that the bins be moved at the Bayonne facility, but the possible use of conveyors between bins in any new trial or experimental facility is not precluded.
>
> Parts from the four divisions of the warehouse--medical supplies, general stores, ordnance, and electronics--apparently must be kept separate for shipping purposes. This makes the problem of accumulating all the material on one order much more difficult and probably means four separate accumulation systems instead of one. While this fact may not be costly from a time angle it is very serious from a "first cost" economic standpoint.
>
> The paper work as now used is cumbersome to an "IBM" automation system and changes would have to be provided for efficient bulk order picking.

The orders now checked and placed on pallets in each of the four divisions are delivered to the packing area. Savings in transportation and consolidation of these four checking areas at the packing area by means of automated conveyors seem worthy of further study as part of an integrated system.

We do not believe it is practical to fully automate even the fast moving items now stored at Bayonne due to the type and nature of some of the products. By "fully automate" we mean to actually release from a bin by remote control the required parts to fill an order and deliver these parts to the checking stations simultaneously with other parts that make up a single order.

We do believe a semi-automated system can be developed that will materially speed up the picking operation by providing a better means of material handling with provision for multiple picking of orders that will permit a larger volume to be handled with little increase in labor.

Without a more detailed engineering study of the entire problem we cannot predict the initial investment required nor the labor requirements to operate such a system. A very preliminary check would indicate that the cost of such a system would not be justified on a purely economic basis with the volume of parts now passing through the warehouse. It is our firm belief, however, that the installation of a semi-automated system would handle a greatly increased volume at little increase in labor and would offer intangible savings that are hard to pin-point such as less damage to parts, fewer losses, better inventory control, and more orderly flow of material through the entire operation. The increased volume potential, also, has a high insurance value against a national emergency.

It is recommended that a research and development program be undertaken to effect a practical and satisfactory semi-automated picking and handling system. There have been many outstanding advancements in the adaptation of electrical, electronic and mechanical equipment to automated handling systems in recent years. We believe these new principles are applicable to the problem as we understand it at Bayonne.[1]

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[1]Jervis B. Webb Company, Detroit, Michigan, Letter, March 28, 1958.

The Webb Company study, and similar studies by other equipment manufacturers, were very valuable. While not offering any specific application for automation that appeared entirely practical and economically justifiable, the studies confirmed the Bayonne research team's findings that some degree of automation was possible in Navy warehousing. The problem the Bureau faced was how far it should attempt to proceed in automating the materials handling functions. It was the opinion of the Bureau that any system developed for peacetime operation must stand the test of economics. It felt that any expensive automated or semiautomated system could not be justified solely on the basis of greater capability for rapid wartime expansion.

Further study and investigation continued. It even extended to Europe where during a business trip to Germany, the commanding officer of the Bayonne supply depot had the opportunity to observe an automated handling system in operation at a large mail order house, "Quelle," located in Bavaria, Germany. The firm handled 20,000 different line items. By means of a network of powered conveyors and a controlling console, customers' orders were automatically conveyed through the warehouse from the storage area to shipping. While the procedures and operations employed were not entirely analogous with those of Navy supply, several of the major features of the system, such as the powered conveyors and controlling console, seemed to be applicable to some of the Navy's warehouse operations.

Until this time, the Bureau of Supplies and Accounts had been thinking in terms of automating the stock picking function at Navy warehouses. Four equipment manufacturers had submitted formal proposals to conduct detailed evaluation studies for application of automation to this function. The Bureau decided not to accept these proposals because of the high cost involved and because the proposals did not solve the major part of the stock picking problem, the picking of unpackaged bin materials.[1]

Although the idea of automating the stock picking operation was not rejected, the Bureau felt it should concentrate on those materials handling functions that appeared easiest to automate. Based on the investigations and studies, these were the materials handling operations involved from the time an item was picked in a bin area to the time it was delivered to a packing station. To proceed with the development of an automated system to handle these functions, the Bureau of Supplies and Accounts requested the Naval Supply Depot in Bayonne to conduct a study of bin storage and issue operations. In its letter requesting this study, the Bureau made these comments:

> The primary step toward mechanization or automation in bin areas is considered to be the installation of a gravity-booster or a powered conveyor line to move material from or to the picking area, with manual handling at both ends. The second step in this program could be the installation of electronic equipment to regulate switching and sorting operations. This would

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[1]U. S. Department of the Navy, Chief, Bureau of Supplies and Accounts, Letter W13, February 24, 1960.

provide for selected stocks being directed to pre-determined customer consolidation stations; or for incoming stores and replenishment stocks to be switched from the main line to holding spurs awaiting placement into bins.

All elements of the warehousing operations are subject to a degree of mechanization or automation but the application of these techniques and available equipment to the bin storage operation is considered to provide the greatest area for improvement.[1]

In conducting the study the Bureau emphasized these factors should be considered:

a. Extent of rewarehousing necessary to establish the required storage environment.
b. Structural or other property alterations or construction.
c. Electrical facilities requirements.
d. Review and selection of available equipment:
(1) Accumulator type conveyor system which will provide for stock picking by traffic function.
(2) A system to provide for controlled sorting by lot number, customer, etc.
e. Number of items to be included in the program.
f. Area requirements for selected items.
g. Percentage of total transactions to be effected.
h. Effect upon supported functions.
i. Maintenance or disregard of class, group, or cognizance integrity.
j. Availability of electronic data processing equipment.[2]

The Bayonne facility completed its study in July, 1959.[3] The findings of this study, coupled with additional work and

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[1]U. S. Department of the Navy, Chief, Bureau of Supplies and Accounts, Letter S83, N6/1, April 7, 1959, pp. 2-3.

[2]*Ibid.*, p. 3.

[3]U. S. Department of the Navy. A Program for Mechanization and/or Automation of Bin Storage and Bin Issue Operations at U. S. Naval Supply Depot, Bayonne, N. J., A report prepared by the U. S. Naval Supply Depot, Bayonne, N. J., July 15, 1959.

planning by the Bureau and several of the field activities, eventually led to the design and development of automated handling systems that have been installed at five of the major stock points. Some of the major planning considerations that preceded installation of these systems will be discussed in the following chapter.

CHAPTER III

PLANNING FOR INSTALLATION

The warehouse component in the Navy Supply System is not unlike its counterpart in a commercial physical distribution system. Both serve as customizing units in the product flow pipeline, customizing referring to the process whereby bulk quantities of stored items are regrouped into shipments based on individual orders. Both have as their objective the efficient movement of materials into and out of the warehouse. As one authoritative source on the subject of physical distribution has noted:

> The distribution warehouse contains goods on the move. Since the operation is essentially a break-bulk and regrouping procedure, the objective is to efficiently move large quantities of products into the warehouse and customized orders of products out of the warehouse.[1]

Although the quantities and variety of items stored may differ and the frequency or distance of movement may vary, warehouses in military and commercial supply distribution systems appear to be analogous in their basic objective--efficient movement of material.

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[1]Edward W. Smykay, Donald J. Bowersox and Frank H. Mossman, Physical Distribution Management (New York: The MacMillan Company, 1961), p. 207.

Analysis of Material Movement

Material movement in most warehouses involves handling; however, handling can be minimized as a result of careful planning in developing the system to be used. Probably the most significant item in planning a handling system is the analysis of material movement.[1] This analysis is a prerequisite to the proper selection of a materials handling system, whether it is manual, mechanical or automated. Smykay and his coauthors highlight this fact when they state:

> Management should clearly understand the nature of the movement requirements in order to appreciate the reason for selecting a specific system. The fact must always be kept in mind that handling, per se, adds no value. . . . Handling and rehandling give the appearance of a busy operation, but they also create a costly operation. The objective in selecting a given materials handling system is to accomplish necessary product handling with a minimum of movements.[2]

In an analysis of the materials movement problem Bolz and Hagemann suggest that the primary concern should be directed toward determining information concerning these four key questions:[3]

1. What material is to be moved and why?
2. Where is the material to be moved and why?
3. When is the material to be moved and why?
4. What is the volume of the material to be moved?

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[1]Immer, loc. cit., p. 79.

[2]Smykay, Bowersox and Mossman, loc. cit., p. 244.

[3]Harold A. Bolz and George E. Hagemann, Materials Handling Handbook (New York: The Roland Press Company, 1958), p. 2.1.

The employment of this approach would probably be applicable to handling problems in any situation. In the case of Navy warehouse operations it is of special importance because, by their very nature, military inventories differ from their industrial counterparts in that a high percentage of stock issues are made from a very low percentage of items carried. For instance, it is necessary to stock large numbers of insurance-type items for which there is infrequent demand. In fact, approximately eighty percent of Navy issues are made from about forty percent of the items stocked.[1] This situation is not the result of bad inventory management, but is a requirement imposed by the military necessity that reserve stocks and critical items be carried in sufficient quantities at strategic locations in order to be available in case of an emergency. As in many industries, the volume of material movement in Navy warehouses varies with the seasons. Also, peculiar to a military warehouse is the fact that changing domestic or world situations can have a fluctuating effect on normal material movement patterns.

While new innovations in materials handling equipments might provide tools for efficient handling of supplies and materials, there are many factors which determine their economy and scope of application, the most important ones being,

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[1]Edward C. Campbell, "Warehouse Automation at NSC, Oakland," Monthly Newsletter, Magazine of the U. S. Navy Supply Corps, Vol. XXVII, No. 2, (February, 1964), p. 25.

especially in the case of warehouse operations, the volume and type of supplies handled and the activity or turnover of such supplies. In the initial planning stage for implementation of an automated materials handling system, the Bureau of Supplies and Accounts recognized that it had to consider these factors if it were to achieve optimum utilization of any new system. To install an elaborate and expensive handling system would be a costly project if only a part of the total percentage of items susceptible for automation could actually be handled on the system. Therefore, one of the first things the field activities had to accomplish was to prepare their stocks for automation. This involved an analysis of the physical characteristics of items carried and their turnover rate, and the subsequent repositioning of such items to ensure storage arrangement would take full advantage of system design.

Because of the vast variety of items stocked in U. S. Navy warehouses, the stock repositioning task could have been an overwhelming one. Two storage improvement programs the Bureau had started prior to 1959, however, ideally complemented the storage lay-out plan that eventually evolved for an automated handling system. The progress already made on these programs helped pave the way for early implementation of an automated handling system. These were the Popularity Storage Program and the Bin Consolidation Program.

In order to fully appreciate how the concepts embodied in these two programs served to facilitate the storage lay-out for an

automated handling system a brief review of earlier storage practices and their inadequacies is pertinent.

The Hicks' Storage Plan

Prior to World War II the quantities, variety and numbers of items in the supply system were infinitesimal in comparison to those stocked today. The storage facilities and handling methods were geared to the times and, by current standards, were relatively crude and inefficient. The first move toward developing an improved warehousing system in Navy supply was organized along the precepts of a cataloging program established by Rear Admiral T. H. Hicks.[1]

Basically, the Hicks' plan provided for the grouping of related items into commodity classes to be supported by a catalog system. The system enunciated by Admiral Hicks adequately satisfied the pre-World War II supply system needs. In fact, the Hicks' plan was the first definite step taken to develop a systematic program for the operation of a military supply system.

The warehousing system under the Hicks' plan required that supplies be physically positioned to conform to the alphabetical-numerical sequence of the stock numbers as established in the

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[1]Rear Admiral T. H. Hicks was the Navy Paymaster General from 1925 to 1928. During his term of office Admiral Hicks laid the initial groundwork for the development of a federal standard stock catalog. In 1929 he was appointed Chairman of the Federal Standard Stock Catalog Board. For a more detailed description of the Navy's first cataloging system see Federal Standard Stock Catalog, Its Origin and Functions, a report prepared by the Bureau of Supplies and Accounts, U. S. Navy Department, Washington, D. C., February 14, 1952.

Admiral's catalog. Space reservations and allocations were made to cover the maximum stocking level of items regardless of their stock status, or whether or not the supplies were on hand or due in. These space reservations were made for all items regardless of their availability, through seasonal deliveries or otherwise.

For the most part, hand stacking upon dunnage was used to effect placement of non-binnable supplies into storage. This was possible, even compulsory because buildings, in the main, were of multi-story construction with relatively low air rights above the first floor. Handling equipment consisted, at this time, of skid platform trucks, portable elevators and hand trucks. Even with low stacking heights and with controlled inventories during periods preceding World War II, much space was wasted and many man-hours were expended to support the plan. Still, it was better than no plan at all and it was recognized as just the beginning step in developing a better warehousing operation.[1]

<u>Cubic Approach to Storage</u>

Although the Hicks' storage concept provided for an orderly and sequential stock location layout, without the need for stock locator card files, it considered storage only on a two dimensional basis. It could not give due consideration to optimum space

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[1]George G. Dewey, "The Evolution of Warehousing," Monthly Newsletter, Magazine of the U. S. Navy Supply Corps, Vol. XXVII, No. 2, (February, 1964), pp. 18-19.

utilization because modern materials handling equipment and storage aids which would facilitate vertical as well as horizontal storage arrangement were unavailable at that time.

With the subsequent development of modern warehouses having high air rights and the introduction of the fork truck-pallet system of materials handling, the inadequacies of the Hicks' system became evident. Industry's appreciation of the deficiencies of this type of stock location system is accentuated by the following quote from an authority on the subject:

> A common error in most industrial warehouse operations is the arrangement of stock in some arbitrary alphabetical or numerical sequence to simplify location. Such systems are costly in terms of wasted space because the warehousing depths are determined by the depths required for the smallest lot. This results in an excessive allocation of space for aisles. It violates the fundamental principle that warehousing depth rather than width should be the governing variable. Few warehouse layouts can be efficiently planned on the basis of a single common denominator of warehousing depths.[1]

The fork lift truck and palletization made possible the cubic or three dimensional approach to storage. Also, storage in an alpha-numerical sequence quickly became impractical with the beginning of World War II and the addition of thousands of new items to the supply inventory.

Positioning and repositioning items to maintain sequence storage gave way to this new and more practical approach to

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[1]John S. Sheahan, "Warehousing for Profit," Cost Controls for Packing, Shipping and Warehousing, American Management Association Packaging Series Number 25, New York, 1948, p. 22.

warehousing--storage by space. With few exceptions, material was no longer stored by stock number sequence, but by group and class within each commodity category. This permitted full utilization of all available space with great emphasis being placed upon the use of cubic storage. There developed, however, the need for a stock locator system under this new storage concept. Because the number of stock items within a class group was relatively small, the Hicks' system was still effective and used in the separate bin areas to which each class was assigned.

As part of the cubic storage principle, a series of more or less autonomous storage operations based on material categories developed at each stock point. Generally, each category had its own retail bin operation, its small, medium and large lot bulk storage areas and, sometimes its own receiving, packing and shipping operation. Within each of these storage components material was stored without regard to stock number sequence, turnover, or any other factor except possibly physical characteristics and group or class.

Popularity Storage

Storage space is a basic resource of any warehouse. Under the cubic approach to storage the supply centers and depots had given recognition to this fact. Labor is a basic resource also; however, sufficient attention had not been directed towards this aspect. The significance of the labor element in warehouse operations is emphasized by the General Services Administration in

delineating basic storage objectives.

> Storage objectives include such factors as . . . effective conservation of time, labor, and equipment. . . . Space and labor are expensive. Efficient storage demands the maximum utilization of space with a minimum amount of labor expended in storing supplies.[1]

In the early 1950's a new concept to storage in Navy warehouses developed--that of positioning stocks by frequency of demand, more familiarly known as popularity storage. Although this was a new theory in Navy storage practices, it was not an original concept. In 1948 an industry official expounded its principles when he wrote:

> The location of the various items in a warehouse--whether raw, semi-finished or finished products--is extremely important from the standpoint of handling costs. The objective is to reduce the travel distance of items in greatest demand. They should be placed near the point of use or shipment.[2]

The principle of storage by popularity insofar as the Navy Supply System is concerned was born, or at least nurtured during its infancy, at the Naval Supply Depot, Bayonne, New Jersey. The concept did not expand system-wide, however, until publication in 1956 of the Storage and Materials Handling Manual. As a result of this manual popularity storage received intensive promotion. This manual emphasized that:

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[1] Warehouse Operations Handbook, General Services Administration, Federal Supply Service, Washington, D. C., April, 1953, p. 28.

[2] Sheahan, *loc. cit.*, p. 22.

> Relative activity or turnover is the first factor to be considered in determining storage location for material. Stocks moving daily should be stored nearest the shipping or break-out area as should the retail bin stocks. Active supplies require many trips between the bulk storage location, retail bin stocks and the shipping areas; therefore the trips should be as short as possible. The retail bins and shipping area should be located near the storekeeper's office for similar reasons; also, the receiving area should be in close proximity to the office. Classes of items which are issued most often will be located near the point of issue. Classes of items with the slowest movement will be located farthest from the working areas.[1]

This principle of location by popularity for a retail bin area in a typical Navy warehouse is shown by Figure 1. It will be observed that fast moving items are readily accessible to the office and workspace and can be selected and issued with a minimum of handling.

Bin Consolidation

As a result of the Popularity Storage Program, most storage activities, either by rewarehousing or by attrition, attained a degree of storage by frequency of demand and benefited therefrom. However, true popularity storage was never attained at any activity because of one overriding restriction, the mandatory requirement that storage integrity of class, group and cognizance be maintained. Navy stock points were segregating

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[1]U. S. Department of the Navy, Storage and Materials Handling NAVSANDA Publication 284, pp. 22-1 and 22-2.

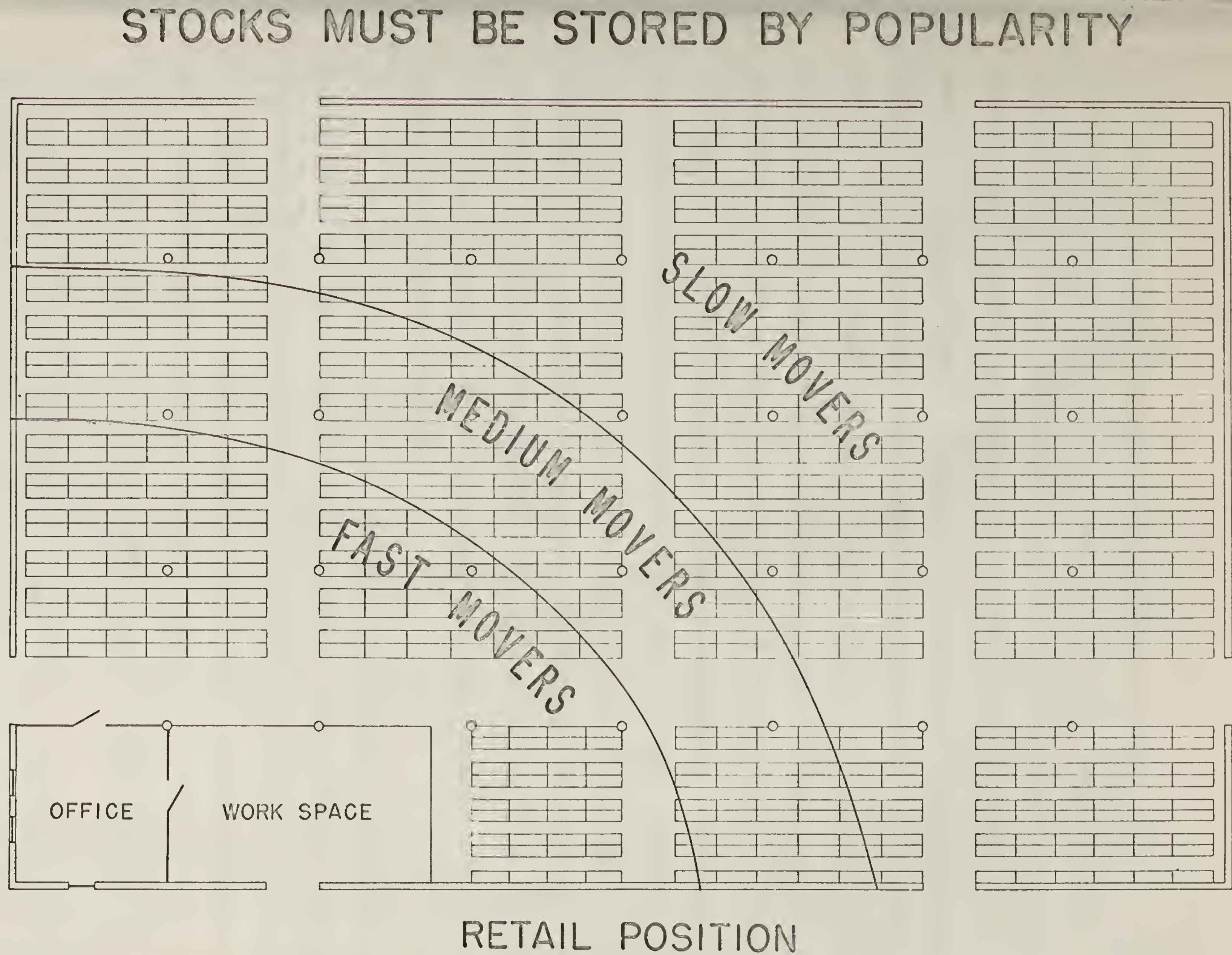

Figure 1.--Popularity Storage for a Retail Bin Area.

stocks by commodity category[1] and within each category by group and class. This storage requirement permitted only limited application of the popularity concept with the net result that there were a number of popularity storage layouts equal to the number of the different categories of material stocked by the activity. Bin storage areas with attendant bulk back-up stock were set up by commodity groups and, consequently, were separated and dispersed throughout the various floors and buildings of an activity. Figure 2 represents a typical storage layout under the storage by commodity group and class restriction. Although popularity storage exists within each bin and bulk storage area, it will be noted under such a storage plan that bin issue operations are scattered throughout the length and breadth of an activity. At some of the larger supply activities this resulted in bin issue operations being dispersed over several separate areas, buildings and floors.

In 1957, as a part of its continuing effort toward the improvement of the material issue function, the Bureau of Supplies and Accounts uncovered a number of thought-provoking and action-demanding facts. Studies revealed that about eighty percent of the items in the Navy supply system were susceptible to bin storage and thousands of these items were not represented in bins,

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[1]The Navy Supply System is predicated upon management of inventories by type or category of material in support of weapon systems. Most items in the inventory are centrally managed at Inventory Control Points, which are established by category of material, i.e., missile and ordnance, aviation, electronics, ships parts, general supplies, automotive and construction, subsistence and fuel.

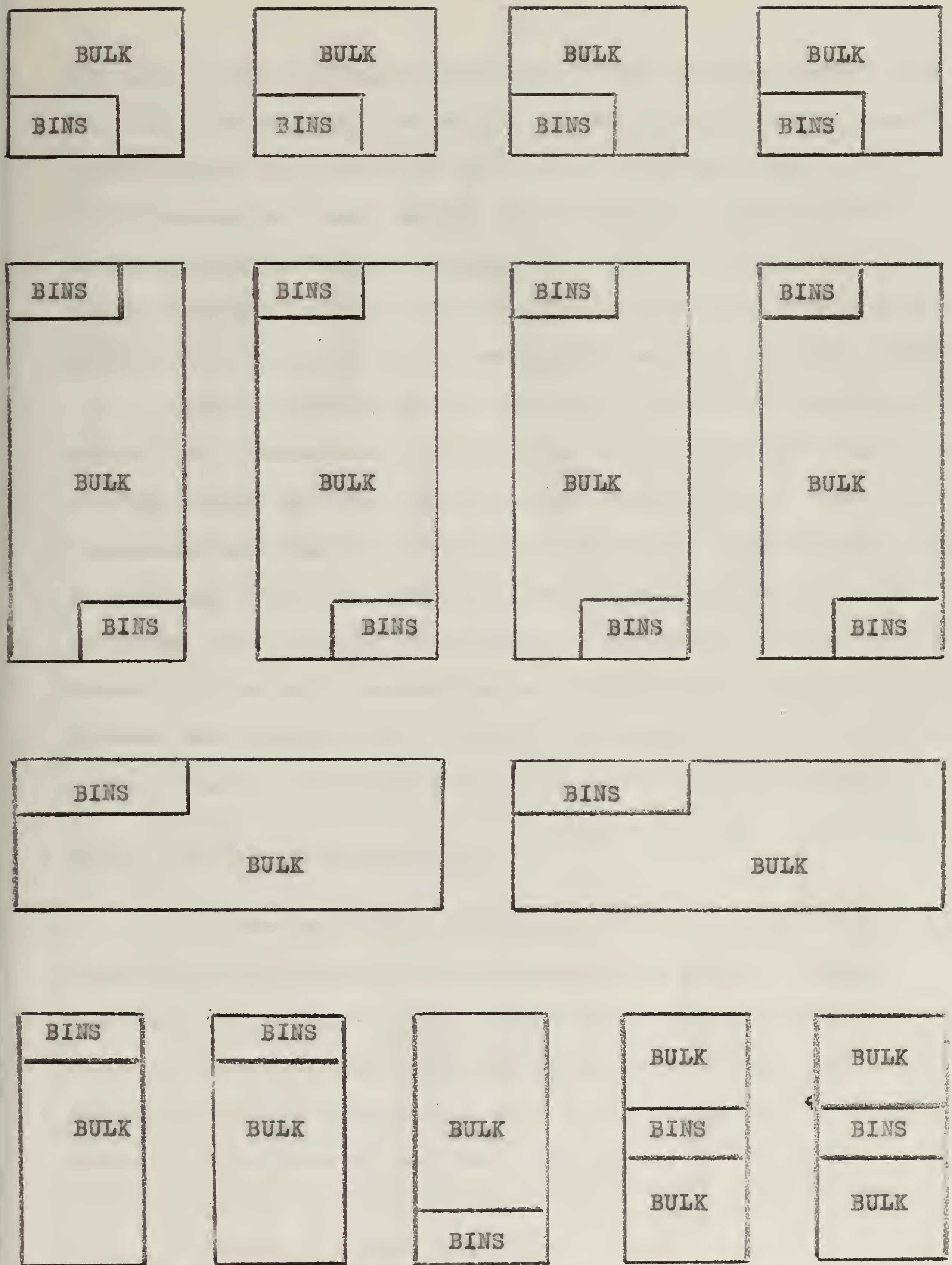

Figure 2.--Typical Storage Layout by Commodity Group and Class Restriction (Before Bin Consolidation).

but were stored in bulk warehouses.[1] The studies also showed that most activities were making approximately ninety percent of their issues from about ten percent of stocked items, and that these ten percent were spread throughout the storage areas. Investigation further disclosed that bin storage operations occupied only ten percent of the storage space at activities but accounted, item-wise, for seventy-five percent of their issues.

These findings opened the door to another improvement in the storage operation--consolidation of an activity's entire bin storage operation into one centrally located area. The Bin Consolidation Program provided for more than just bringing all established bin areas into one floor of a centrally located building. It required also that the thousands of bin type items stored only in bulk warehouses be represented in the one centrally located bin storage area. Figure 3 illustrates a representative storage layout after implementation of bin consolidation.

<u>Other Planning Considerations</u>

Another important factor in selecting a materials handling system is an analysis of the number of different customers serviced, the number of line items requisitioned by each customer, and the method of pack and mode of shipment to be used. Greater economies can be realized if all, or the majority, of a customer's orders can be accumulated and consolidated into a single pack for

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[1]Dewey, <u>loc. cit</u>., p. 20.

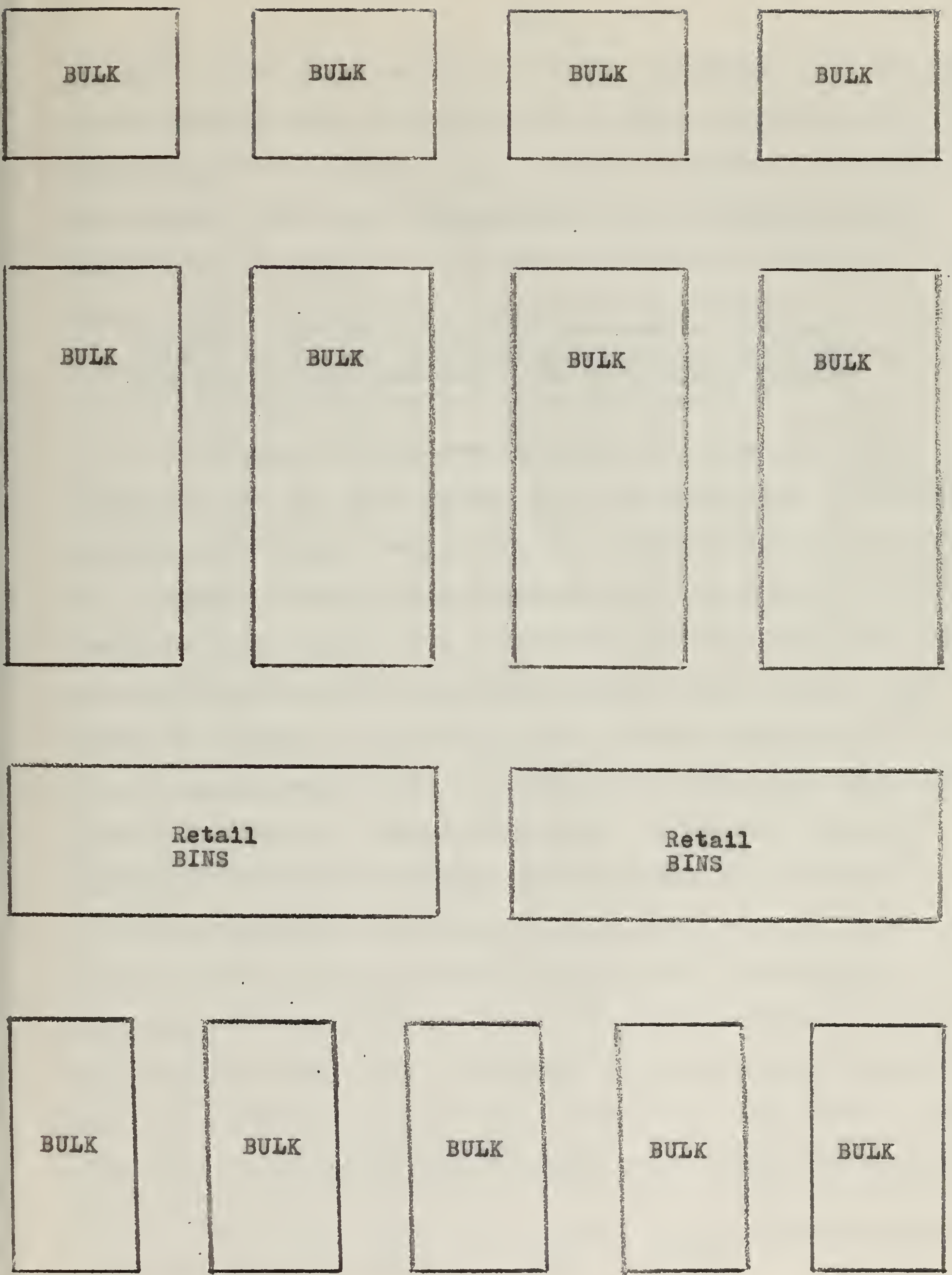

Figure 3.--Storage Layout After Bin Consolidation

shipment rather than having to utilize a separate pack for each item requisitioned. Not only will handling be minimized by such consolidation but transportation costs on outgoing shipments will be reduced. The Navy Storage and Materials Handling Manual emphasizes the importance of the consolidation principle:

> Unit loads should be increased to economic maximum. Greater economy is obtained as the unit load is increased, provided container or equipment capacity is not exceeded. The more pieces carried in one load, the greater the efficiency.[1]

Although maximum consolidation of orders is highly desirable for the stock points from the standpoint of reduced handling, there are two constraints that restrict this practice to a degree. First, every shipment made from a supply center or depot must be received and processed by another activity. Most of the activities which the stock points support store their items by category of material; i.e., medical supplies are stored in a separate area from electronic parts, hand tools and other types of material. The receiving and distribution to store functions at these activities are therefore facilitated if incoming shipments are packed and separated by type of material. Consequently, reduced handling costs through consolidation at the shipping activity could well mean increased handling costs at the receiving activity. Therefore in planning for accumulation of orders the stock points had to take into consideration that what might be a gain at the shipping point might result in a loss

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[1]U. S. Department of the Navy, Storage and Materials Handling, NAVSANDA Publication 284, p. 41-3.

at the receiving point.

A second constraint the stock points had to consider in planning the method and degree of accumulation was the difference in transportation rates applicable to various categories of material. For example, expensive and fragile electronic parts carry a higher freight rate than do less expensive and more rugged items, such as hand tools. A package containing both electronic parts and screwdrivers is rated on the basis of the more expensive item, in this case, the electronic parts. The economy in handling obtained by combining a customer's total order could thus be neutralized or even result in a more costly final product as a result of the varying transportation rates for different types of commodities.

An analysis of the daily issues at the various stock points revealed that many customers were ordering five or more line items daily.[1] Some of the bigger customers serviced, such as the major air stations and shipyards, often had demands peaking to more than 100 line items per day. These data emphasized that some means of customer order accumulation was highly desirable, in spite of the countervailing considerations of variance in transportation rates by type of commodity and the handling problems at the receiving activity. Thus, in planning

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[1]U. S. Department of the Navy, Bureau of Supplies and Accounts, Unclassified Files of the Materials Handling Branch, Warehouse Operations Division.

the materials handling system the Bureau of Supplies and Accounts determined that system design should incorporate features which would enable a customer's total order to be staged so that the individual line items in the order could subsequently be assembled by commodity category.

Navy supply system distribution not only covers the United States but embraces almost the entire world. It extends from a ship at dockside in Norfolk to a ship on duty in the Mediterranean, from an activity in Hutchison, Kansas to a naval communication station in Asmara, Ethiopia. Shipment of items to such widely spread points involves many different methods of pack as well as diverse modes of shipment. Transportation of outgoing shipments is provided by means of local delivery, common carrier, and the postal system, using trucks, railroads, airplanes and ships. Many items issued to customers can be forwarded in the manufacturer's pack without the need for repacking and cushioning prior to initiating shipment. Such items merely require preparation of the applicable shipping documents and proper stenciling and marking to ensure safe delivery to the consignee. On the other hand, many items cannot be forwarded in the original pack and have to be prepared for shipment utilizing appropriate barrier and cushioning materials. In planning the optimum handling system consideration had to be given to these factors. Special packing lines by type of pack to be used and mode of shipment to be employed had to be designed into the system in order to accrue the benefits of

specialization of labor and orderly material flow to the shipping operation.

Along with an analysis of the material movement pattern in Navy warehouses a study was made of the accompanying paperwork requirements. The initial research studies had pointed out that prior to the installation of any automated warehousing system, the existing paperwork system should be carefully studied and revised where necessary to ensure its compatibility with the physical movement of material under an automated system. Based on a study of the paperwork requirements it was determined that processing of material for issue and shipment on single line item documents would be a prerequisite to an automated system.[1] Single line item document meant that only one individual item could be requisitioned and issued on it. The Department of Defense, Military Standard Requisitioning and Issue Procedures (MILSTRIP) implemented in early 1960 satisfied this requirement. MILSTRIP procedures required all military activities to requisition and issue supplies on the basis of a single line item document.

In summation, the major constructs under which the Bureau of Supplies and Accounts and the field activities prepared for and ultimately developed an automated materials handling system were: storage of materials was to be arranged by frequency of demand, all binnable items were to be consolidated and stored in retail

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[1]U. S. Department of the Navy, Commanding Officer, U. S. Naval Supply Depot, Bayonne, N. J., Letter 300 (JJD/rdk), July 17, 1959.

bins, a system of programming and scheduling each day's issues was to be devised to take advantage of customer order accumulations, revised packing layouts were to be drawn up to ensure specialization by type of pack, and finally, as a result of MILSTRIP, a paperwork system evolved that was compatible with automated warehousing.

CHAPTER IV

DESCRIPTION OF THE SYSTEMS AND THEIR MANAGEMENT

Selection of the First Site

Warehouse automation had its birth at the Naval Supply Center, Bayonne, New Jersey. Bayonne was selected as the site for installation of the first automated materials handling system primarily because of three factors. First, it had already created a completely consolidated bin and popularity storage situation which provided an ideal environment for initiating automation.[1] Extensive rewarehousing of stocks was therefore not necessary to prepare it for automation. Of the 303,000 total line items carried, approximately eighty-five percent, or 250,000 items, were already stored in retail bins under the popularity storage concept.[2] Second, some of Bayonne's senior warehouse personnel had participated in the initial pilot studies and had continued to work closely with the Bureau of Supplies and Accounts and the Naval Research and Development Facility in developing automated warehouse procedures and planning a system design. As a consequence, the key

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[1]Edward C. Campbell, "Push-Button Warehousing," Monthly Newsletter--Magazine of the U. S. Navy Supply Corps, Vol. XXIII, No. 10 (October, 1960), p. 16.

[2]U. S. Department of the Navy, Naval Supply Center, Bayonne, New Jersey, Material Department Procedure for Mechanization and/or Automation of Materials Handling from Pick to Pack, 1960, p. 1.

warehouse supervisors were already familiar with many of the operating procedures that would be employed in an automated system. The third influencing factor for selecting Bayonne as the initial site was its type and volume of business. While Bayonne was not the largest supply activity in terms of number of line item issues per day, studies had revealed that its warehouse workload was of sufficient magnitude to warrant automation and its type of business readily lent itself to programming for customer order accumulation. It was averaging 5,800 expenditure line items per day for nine different material commodities. Of these 5,800 issues, eighty percent, or 4,500 items, were being effected from the retail bin source. An average of 3,400 line items of the 4,500 retail bin issues were being issued to 131 different customers providing an average of twenty-seven line items for each of these customers that could be programmed for accumulation.[1]

In July, 1959, Bayonne had prepared a proposal for automation of bin storage and bin issue operations. Primarily, on the basis of the information contained in this proposal, system design specifications were prepared by the Bureau of Supplies and Accounts and submitted for bids to materials handling equipment manufacturers. In June, 1960, a contract was awarded to the

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[1]U. S. Department of the Navy, Bureau of Supplies and Accounts, Unclassified Files of Equipment and Materials Research Division.

Rapids-Standard Company, Incorporated, Grand Rapids, Michigan[1] to install a system for the handling, moving, sorting and accumulating of material, which would include take-away conveyors, customer accumulators, various commodity sorts and a controlling console. The Bayonne system was installed during the period September to December, 1960, and operations under automated handling commenced in January, 1961. Since that date automated materials handling systems have been designed for six additional major stock points: The Naval Supply Centers at Norfolk, Oakland and Charleston; the Naval Shipyards at Long Beach and Puget Sound; and the Naval Supply Depot in Philadelphia. The systems at Norfolk, Oakland, Charleston and Philadelphia are operational. The Long Beach and Puget Sound systems are expected to be operational prior to January, 1966. Each of these systems has been individually tailored to the business volume and the warehouse structural characteristics of the particular activity.

Point of Issue Concept[2]

As an introduction to a description of the distinguishing features of the various systems it is necessary to explain the "point of issue" concept that evolved and is employed in each

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[1]Campbell, loc. cit., p. 15.

[2]U. S. Department of the Navy, Chief, Bureau of Supplies and Accounts, Letter S83 N6/1, April 7, 1959, p. 1.

automated materials handling system. The principle of storage by frequency of demand created a concept of a "point of issue" which required that the fast moving or most popular items, in either bin, rack, or bulk storage, be positioned in an "up front" location; i. e., nearest the office and work space. The medium and slow moving items would then be positioned progressively away from the point of issue. (Refer to Figure 1, page 38.) The use of conveyor lines in an automated handling system revises this "point of issue" concept in that the portion of conveyor line which passes through a bin area becomes a "point of issue." This concept provides for positioning the fast moving items within a few feet of the new "point of issue" (the conveyor line) and positioning the medium and slow moving items progressively farther from the conveyor line. Figure 4 illustrates this new point of issue when a conveyor line is used between bin aisles.

Distinguishing Features of the Systems

The automated materials handling systems are centrally operated, electronically controlled, electrically powered conveyor systems used for the movement of material received into or issued out of a storage warehouse. The systems are similar in operation to an extensive model railroad system, with tote pans[1] moving over

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[1]Tote pans are open top plastic boxes used to transport receipts and issues to and from the warehouse bin areas. They are designed to handle a maximum weight of seventy-five pounds.

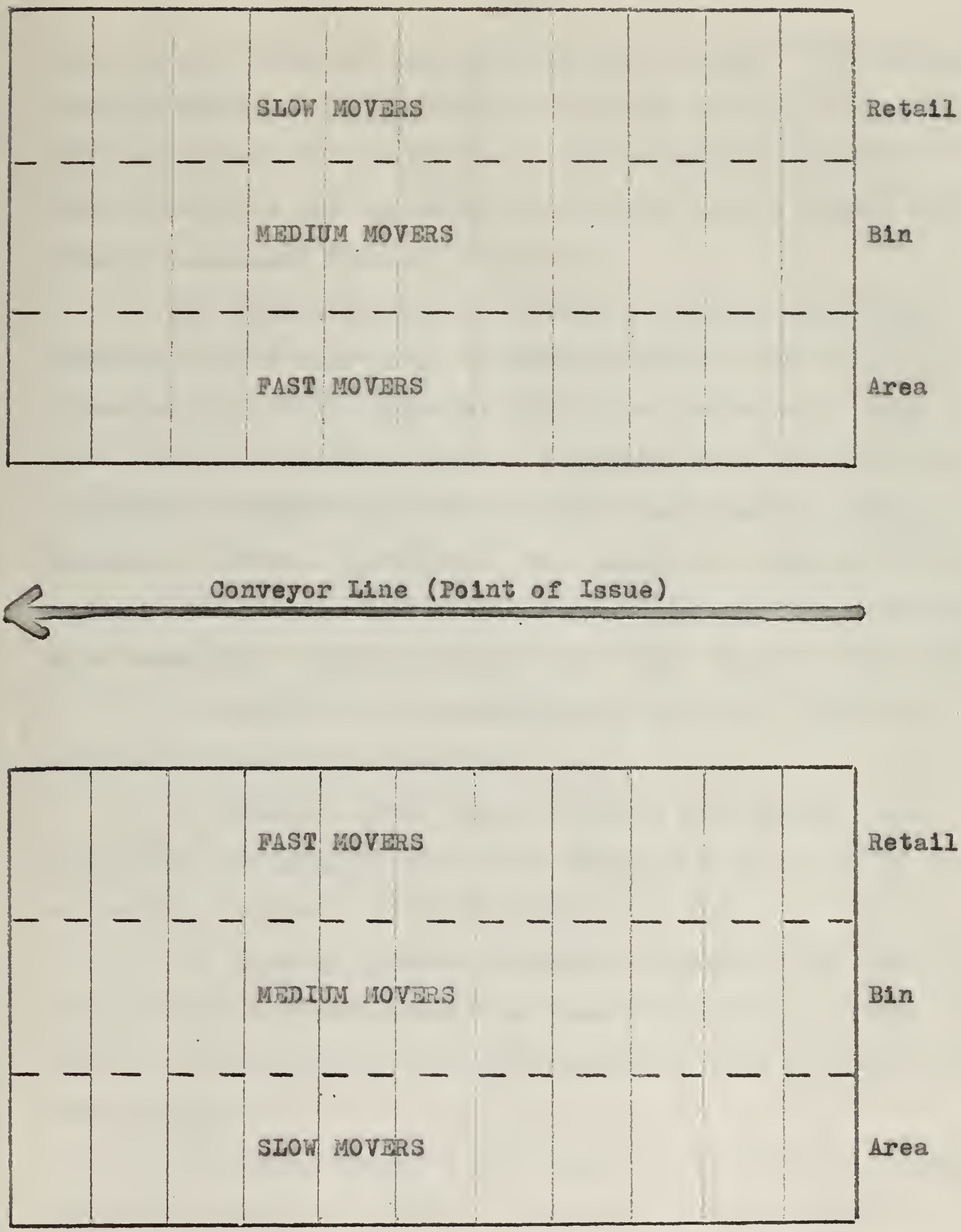

Figure 4.--Conveyor Line "Point of Issue" Concept

the conveyor lines in lieu of cars over a track. The present installations can be generally classified as either simultaneous pick or sequential-pick systems. These general system classifications may be further subdivided by the method used to signal electronic routing of orders.

The simultaneous pick system is designed for those activities that have many customers ordering five or more line items daily. It is characterized by the location of fifty to sixty conveyor holding lines in a packing area which are used as a tote box marshalling yard to allow simultaneous accumulation of orders for several customers. The automated materials handling systems at Bayonne, Norfolk and Oakland feature the simultaneous pick operation. Issues are made over this system as follows:

1. Each order containing more than five items is assigned a specific accumulator line.

2. Orders, after being combined into groups, are scheduled for issue so that each accumulator line may be assigned to several different customers during the day.

3. Picking tickets (MILSTRIP documents) are distributed to appropriate stock pickers who remove the desired items of an order group from bins in accordance with a time schedule assigned that group.

4. Stock pickers route each item through the conveyor system by setting the proper signal on a device attached to the side of the tote box.

5. Multiple item orders are collected automatically on a predesignated accumulator line. On release from the accumulation line, each order is sorted by freight classification then moved through the packing, stenciling, weighing and strapping operations to the shipping area.

6. Small orders (less than five items) not requiring accumulation and items in original packs are routed directly to packing or shipping, as appropriate.

The sequential pick system is used on the Charleston and Philadelphia conveyor systems since the majority of their customers order less than five line items. These systems do not contain accumulator conveyors. They contain, instead, short conveyor sidings intermittently located along the main conveyor lines running through the bin areas. Under these systems, by means of advanced scheduling, each customer's order is assigned one or more tote boxes which are routed through the conveyor system as a unit. The signal device on the lead tote box diverts the unit into each appropriate picking area conveyor siding in turn. Thus, each item of an order is picked in a pre-set sequence and then released to the packing area. Although the Charleston and Philadelphia systems do not incorporate accumulator lines it should be understood that the sequential pick system does allow for accumulation. By means of routing the tote boxes containing a customer's total order through as a unit, desired accumulation is effected.

The conveyor systems discussed above can be further subdivided by type of signal mechanism used on the tote boxes. The automated materials handling systems incorporate three types: electromechanical, magnetic and photoelectric.

The electromechanical signal system is used with the Bayonne and Norfolk installations. The signaling device which activates the controls for this system consists of metal keys and a punched card. All tote box routings, other than accumulations, are made by depressing appropriate keys. Accumulation by customer is effected by a prepunched card. The signals are read by electrical contact of metal fingers with the keys or holes in the punched card, located on the side of the tote box.

The magnetic signal system is used with the Charleston and Philadelphia conveyor systems. The signal device which activates this system consists of twenty-three magnets, one of which is a fixed reference point. The remaining twenty-two magnets are arranged in two horizontal lines and each magnet may be moved vertically to either an off or on position. This signal is read when the tote box containing the signal device passes in close proximity to the electro-magnet contained in the reading device.

The supply center at Oakland uses a photoelectric signal system with its automated handling system. The signal device which activates this system consists of four reflecting surfaces of which one is a fixed reference point. Each of the other reflectors may be moved to any one of several horizontal positions.

Signals are set for the accumulation line assigned and the material category sort area by moving the sliding reflecting surfaces horizontally. The reading device is activated when the reflected light strikes the photoelectric cell.[1]

Procedures and Operations[2]

A detailed description of procedures and operations at each of the activities where automated materials handling systems have been installed will not be attempted in this paper. Procedures and operations among the activities vary to some extent due to the nature and volume of business and the physical design of the layouts. However, for a proper understanding of how the systems basically function it will be helpful to briefly describe the procedures and operations employed in an automated handling system at one of the supply activities. The system installed at the Naval Supply Center, Norfolk, Virginia has been selected for this purpose primarily because this supply center is the largest in the Navy in terms of volume of business. The Norfolk system incorporates the simultaneous pick system since it has many customers that request five or more line items daily.

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[1]Sharp, loc. cit., pp. 26-29.

[2]The information to describe the operations and procedures of an automated materials handling system was derived from a brochure prepared by the Naval Supply Center, Norfolk, Virginia entitled, Automated Materials Handling System, May 19, 1961.

After customers' orders have been received and initially processed through the paperwork complex, the documents representing those line items on hand are forwarded via a pneumatic tube to the warehouse for issue action. The invoices are delivered to the programming office, which is the nerve or control center of the automated materials handling system. Here the invoices are first sorted into two categories--nonaccumulator type (customers with four line items or less), and accumulator type (customers ordering five or more line items.) After the sorting operation is completed the nonaccumulator type invoices are given to mail clerks for preparation of parcel post shipping labels since experience has shown a high percentage of nonaccumulation orders will be susceptible to parcel post shipment.

Accumulator type invoives are given to clerks for programming these issues through the system. In programming for accumulation the customers' invoices are broken down into four lots, with fourteen customers assigned to each lot. Each customer in each lot is assigned an accumulator line. For example, customers one through fourteen in the first lot are assigned accumulator lines one through fourteen, respectively; customers fifteen through twenty-eight in the second lot are assigned accumulator lines fifteen through twenty-eight, respectively; and so on until fifty-six accumulator lines are assigned. Each invoice requires a prepunched lot number card that corresponds to the lot number and accumulator line assigned. A lot card is then filled out for each customer showing the lot number, accumulator line assigned and the number of items to be accumulated

for that customer. These cards are forwarded to the console operator for display on the console panel in order to control the orders through the system.

After the programming operation has been completed, the invoices with the attached lot number cards are forwarded to the bin area for issue action. Warehousemen receive the documents in picking sequence. Figure 5 shows a picture of a typical bin area operation. The light indicator at the top of the picture is controlled by the console operator and indicates that lots 1, 2, and 3 may be placed on the conveyor belts in tote boxes. Each item for accumulation is placed in a tote box. The prepunched coded card received with the issue document is placed in the card holder located on the side of the tote box as shown in Figure 6. This card will direct the tote pan into the appropriate accumulation line. The warehouseman depresses the proper cognizance symbol indicator on the side of the tote pan. An indicator in a down position will ultimately direct the tote pan into a secondary sort area where material will be staged by type of commodity.

Figures 7 and 8 depict a reading station and a diverter. The reading station is comprised of metal fingers that decipher the coding on the punched cards and the cognizance symbol indicators on the side of the tote box. The reading station electrically trips the diverter (a metal arm) when necessary. This arm directs the tote box into the proper conveyor line.

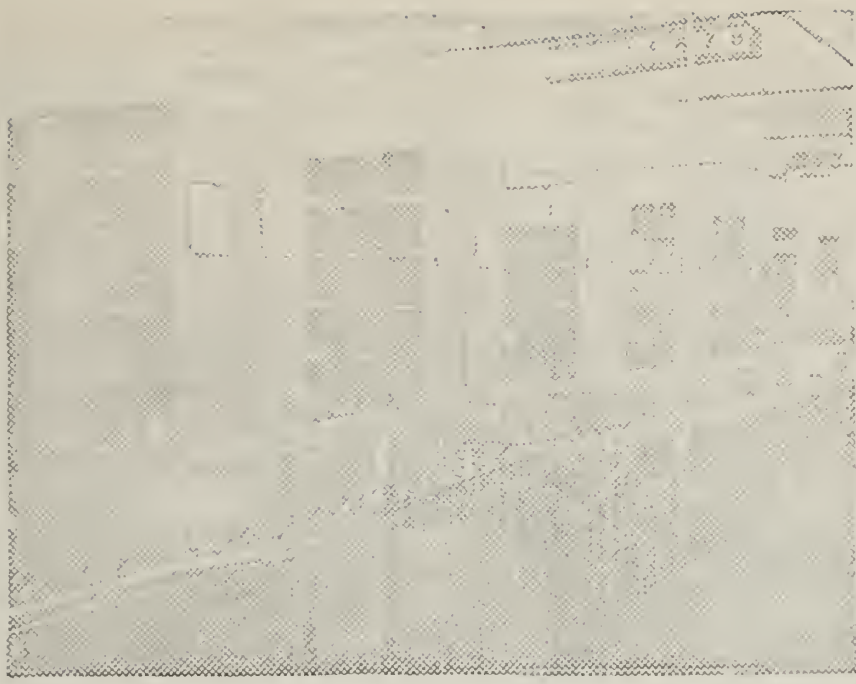

Figure 5.--Typical Bin Area Issue Operation

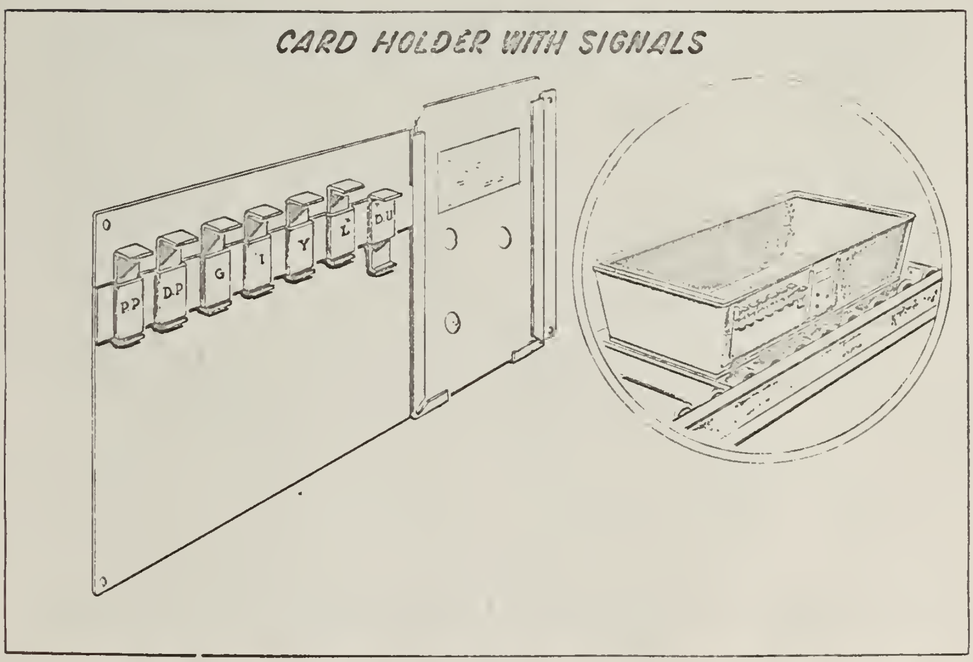

Figure 6.--Tote Pan Used with Automated Handling System

Figure 9 shows the console control panel. This console controls the accumulator orders and feeds the orders to the various packing stations. The console panel consists of fifty-six card holders which represent the fifty-six accumulator lines, a lot number indicator, a schematic of the secondary sort lines and holding lines, and a schematic of the packing stations.

The numbered lot cards received from the programming office are inserted in the card holders in corresponding numerical order. Each number on the console represents an accumulator line and has a tote box counter directly beneath it. When a tote box arrives in a particular accumulator line, the counter automatically adds one to its total. When the number on the counter equals the number shown on the lot card, that particular line is ready for release. When an accumulator line is ready for release, the console operator activates a switch that releases all tote boxes in that line. These boxes are then conveyed to the secondary sort lines where they are separated into appropriate commodity categories by reading stations and diverters. The console panel indicates to the operator when this sort has been completed. When the sort is finished the operator activates a switch to release the tote boxes from the secondary sort lines into holding lines for ultimate delivery to the packing stations.

The control console enables the operator to determine by a glance at indicator lights which packing lines are in operation, which stations have an excess or scarcity of work and to spot trouble areas that might have developed. By proper manipulation of the electrical switches on the panel the operator can activate or deactivate the various automatic stations that control the flow

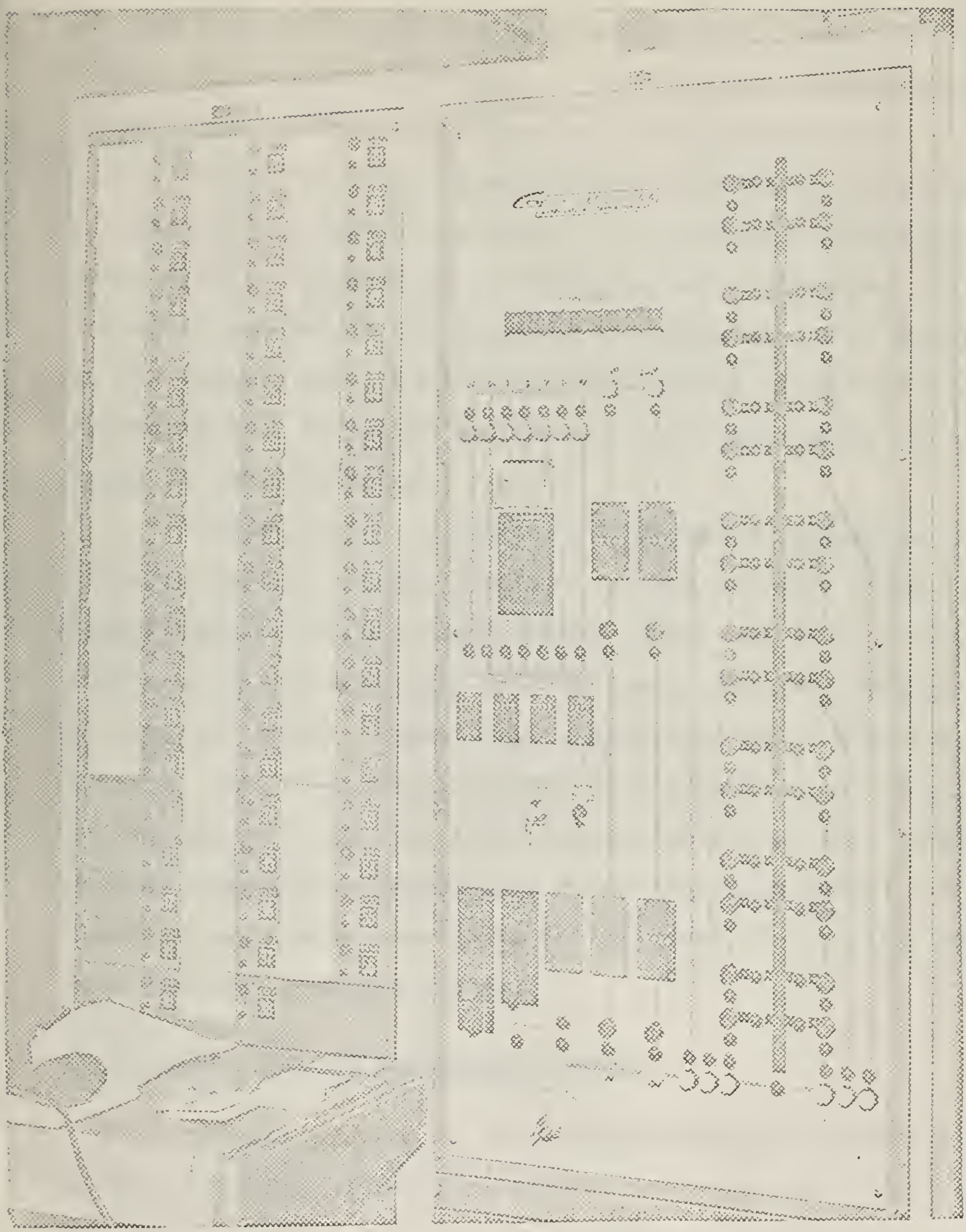

Figure 9.--Console Control Panel

of tote pans from various staging and holding lines, and can signal all warehouse personnel as to the time of starting and stopping the picking operation for certain issue lots.

After the appropriate packing, stenciling and marking of material has been accomplished, the shipping containers are automatically conveyed to the shipping area where they are assembled and loaded for delivery to the consignee. Depending on the weight, cube, destination and urgency of the material, shipments will be packed and shipped via parcel post, air freight, train or common carrier.

Figure 10 is a schematic of the entire automated materials handling system at Norfolk except for the conveyor lines which extend through the bin issue areas. There are four primary conveyors of approximately 600 feet each which run through the bin storage areas. These lines converge at point B on the drawing. The system services 80,000 different line items with an average of 6,500 line items issued daily over it. It has a maximum capacity to accommodate 9,500 line item issues per day, therefore expansion capability in the event of an emergency has been designed into the system.

Organization for Effective Management

Complex systems as these do not function optimally without an effective organization to provide the necessary direction and control. In discussing materials handling activities in general,

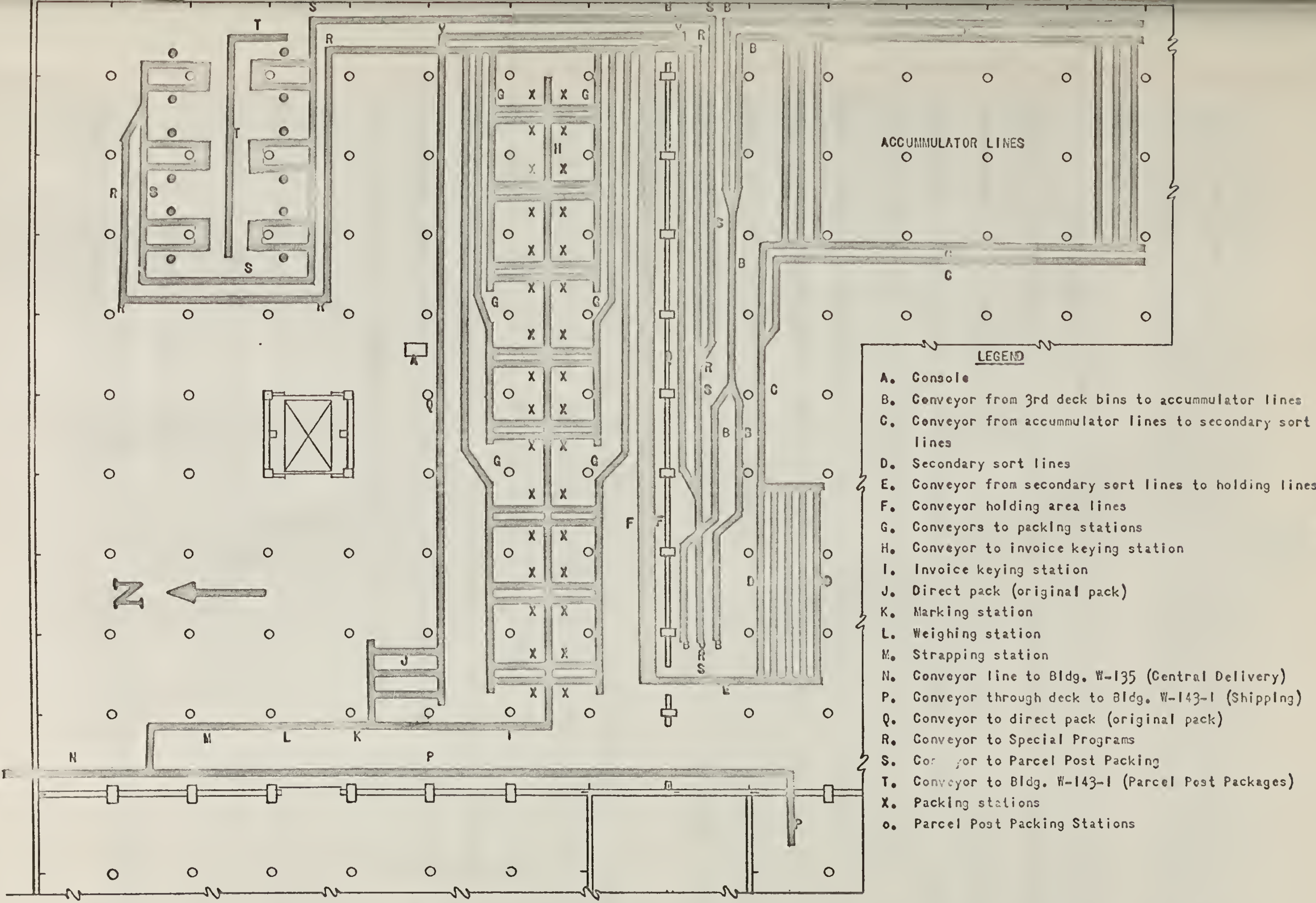

Figure 10.--Schematic of the Automated Handling System at the Naval Supply Center, Norfolk, Virginia

Immer emphasizes that in order for any handling system to derive its maximum benefits it should have centralized direction and control.[1]

Management of the automated materials handling systems can be classified on the basis of technical and operational management responsibility. Within the Bureau of Supplies and Accounts organization the Materials Handling Branch is specifically responsible for the technical management of the systems. The individual commands at which the systems are installed, however, exercise operational management control over the systems. This type of split management is not conflictive in responsibility nor does it contradict the centralized management concept posed by Immer.

The Materials Handling Branch is primarily concerned with broad policy matters relating to materials handling requirements at all of the Navy's stock points. Based on its review of system-wide requirements, the Materials Handling Branch conducts research and develops new materials handling equipments and systems for improving handling methods at the field activities. It also reviews the performance and utilization of materials handling equipments, and, where appropriate, initiates action to effect necessary design changes and modifications.[2] During the

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[1]Immer, loc. cit., p. 313.

[2]U. S. Department of the Navy, Bureau of Supplies and Accounts Organization Manual, pp. OH-28 to 29.

installation of an automated materials handling system at an activity the Materials Handling Branch also works closely with the cognizant warehouse supervisors in developing procedures for the effective operation of the system. Once a particular handling system is installed, however, it is incumbent on the activity to ensure its effective operation.

Each of the supply centers and depots are organized on a functional basis. All warehousing operations are the responsibility of the Material Department. Warehousing embraces all intra-depot materials handling activities. This includes receipt, storage, and issue of material and packing material for shipment. These functions are assigned to two major operating divisions. The Storage Division oversees all receipt, storage and issue operations. The packing function normally is a responsibility of a separate division entitled Services Division.

This type of functional alignment of responsibilities has proved satisfactory for effective management of most materials handling operations; however, in the case of an automated materials handling system it is not always the most desirable. This is because the system itself encompasses the packing function for those items moving over it. Some of the supply centers and depots have therefore found it necessary to modify the standard organizational arrangement to include under a single division that part of the packing function applicable to the automated materials handling system. Where such realignment

of this function has occurred it has been placed under the Storage Division principally on the basis that this division has the responsibility for the major part of the system, i. e., programming and effecting issues and receipts of material over the system.

The advantages of this type of organizational arrangement for managing an automated materials handling system have been recognized by the Bureau of Supplies and Accounts. Soon after the automated handling system was installed at the Naval Supply Center, Oakland, that activity proposed that the packing function applicable to the automated materials handling system remain a responsibility of the Services Division. In response to this proposal the Bureau stated:

> BuSandA considers that the automated materials handling system installed in the bin storage area must have unity of direction to realize its fullest potential. The split responsibility proposed for the packing function performed within the automated materials handling system does not appear to provide such unity of direction. As packers will be required in the automated area on a continuous basis their permanent assignment should enhance control and, thus, productivity. Accordingly, NSC, Oakland is requested to reconsider its proposal and to consider, instead, the feasibility of permanently assigning packers to the bin storage area. Such permanent assignment would:
>
> 1. Provide the supervisors of the Bin Storage Branch with the total control over all facilities to fulfill his assigned responsibility.
>
> 2. Permit direct supervision over all personnel involved in the operation of the automated materials handling system, including day-to-day assignment, overtime and leave control, on-the-job training, performance rating, etc.

3. Provide greater productivity because employees will identify themselves as members of the automated materials handling system team and because of the increased familiarity with job specifics which grows out of permanent assignment.

4. Avoid the problems of dual supervision including conflicting instruction, excessive supervisory interference, unnecessary number of personnel loitering in the work area, employee confusion and attendant low morale.

4. Improve manpower utilization by facilitating temporary reassignment of packers during packing workload lulls.

6. Eliminate the need for resolution by the Material Officer of such details as day-to-day assignment of packers.[1]

Personnel Training

Training of personnel to operate the automated handling systems commences during installation. This is essential because regardless of how good a system is in theory, in practice it will only be as efficient as the personnel who operate it. Training is provided for both supervisory personnel and the general warehouse workforce consisting of stockmen, clerks and packers. Although these personnel are basically proficient in their respective trades, the automated handling systems necessitate that everyone working with it have at least a layman's knowledge of how it operates.

The manufacturer installing the system normally provides some training on system operation to the key warehouse supervisors. These supervisors, in turn, hold general indoctrination sessions with the various operating personnel to ensure their familiarity

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[1] U. S. Department of the Navy, Chief, Bureau of Supplies and Accounts, Letter M1, July 1, 1961.

with the equipment and procedures. Instruction in safety precautions is also provided to reduce the possibility of serious accidents that could result from the many moving parts of the system.

More specialized training is provided for the programming clerks and the console operators, the key elements in the system. The efficiency by which these personnel perform their jobs will determine how well the total system functions. In addition to classroom training, an operating and procedures manual is distributed to the programming clerks and console operators to serve as a guide in programming and controlling material movement over the system.

Statistical Records Control

Even with properly trained personnel and standard operating procedures it would not seem very logical to plan and install an elaborate materials handling system and then expect it to function at optimum performance. Thus, management needs a method of determining if a system is operating in accordance with prescribed plans, or better still, a way of knowing if the plans need to be revised. The responsibility of managing these systems effectively extends to the development and use of a control system, to compare the results of operations with the plans, and adjust future action accordingly. Bolz and Hagemann emphasize that to insure effective production operations, control must be performed. In relation to

materials handling equipment, they state: "Control is essential since it maximizes the use of such equipment, regulates the use of equipment and personnel, and evens up fluctuations in their use."[1]

Control is especially important in an automated materials handling system. There are many factors to consider. For example, one of the major features of the system is the provision for customer order accumulation. How can it be determined that the desired degree of accumulation is being achieved? The key to effective accumulation is prior scheduling. Thus, in order to ascertain the number of line items being accumulated per customer, it is necessary to record a daily count of the number of customers programmed for accumulation and compare this with a similar daily record of the number of line items programmed for accumulation. Using these data, management will have the information it needs to determine if effective programming is being achieved.

Staffing of the system is also important. Placing an excess number of pickers and packers in the bin and packing areas, in relation to the workload, will result in lower productivity rates than would be possible if optimum staffing could be derived. On the other hand, if the line were staffed with an insufficient number of workers, backlogs and jam-ups on the system could develop. Such a situation could also prevent the supply activity

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[1]Bolz and Hagemann, loc. cit., p. 7-1.

from processing customer orders within the standard issue time frames established by the Department of Defense. The previous day's backlog of work, as well as the current day's workload, must be taken into consideration in determining balanced staffing requirements.[1]

The supply centers and depots at which automated handling systems are installed have developed and placed in use various statistical control records to assist in the effective management of the systems. Pertinent data on the systems are collected daily and graphically plotted on control charts. By analyzing trends and patterns in these data management can determine if desired results are being obtained.

For purpose of illustration a selected group of seven control records used with the automated handling system at the Naval Supply Center, Norfolk are included in Appendix A. These records are fairly representative of the types of controls all of the activities use in controlling the systems and determining staffing requirements.[2]

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[1] <u>A Review of the Automated Materials Handling System Operations</u>, A report prepared by the Material Department, U. S. Naval Supply Center, Norfolk, Virginia, February 9, 1962.

[2] Personal interview with Mr. Edward C. Campbell, Director, Materials Handling Branch, Bureau of Supplies and Accounts, Navy Department, Washington, D. C., January, 1965.

CHAPTER V

COST-SAVINGS APPRAISAL

The primary objective of the Bureau of Supplies and Accounts in automating warehouse operations is to increase its ability to service the Navy's fast-moving fleet. A corollary, and no less important goal, is to reduce the handling costs at the stock points.[1] Dollars conserved in the stock points' support functions, such as in the case of materials handling, can ultimately be used to finance the cost of expanding inventories or returned to the taxpayer in the form of a reduced budget to support the defense effort. The question arises then: Are the automated materials handling systems paying their way?

Amortization

Automated handling systems are expensive. Complex hardware featuring several thousand feet of conveyor line, numerous electronic controls and automatic switching devices can be expected to carry an expensive price tag. Since the first system was installed at Bayonne, N. J. in December, 1960, the total investment cost for all of the automated handling systems that

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[1] Campbell, loc. cit., p. 27.

have been completed and are operational has amounted to $4 million. Additional expenditures of $6 million are planned between now and Fiscal Year 1970 for a total investment in automated handling systems of $10 million. Shown below are the costs of installation of the systems at each activity and the annual rate of savings being derived. These savings are based on reduced requirements for personnel only and do not include such cost avoidances as reduction in packing materials, pallets, and rolling equipment that result from the systems.

Activity	Date Installation Completed	$ Cost of System	Annual Rate of $ Savings
NSC Bayonne	12-60	449,000	260,000
NSC Norfolk	2-61	824,000	230,000
NSC Oakland	8-63	1,942,000	675,000
NSC Charleston	4-63	364,000	93,000
NSD Philadelphia	8-63	385,000	75,000
		3,964,000	1,333,000

Based on the annual savings rate accruing at each activity it will be noted that the systems are being amortized within three years. It should also be observed from the above figures that the Bayonne and Norfolk installations have already paid for themselves.

The additional automation in materials handling systems the Bureau has scheduled over the next five years for other activities is expected to yield similar results. An extension in automation to include bulk items and the shipping and receiving functions is scheduled for the naval supply centers at Norfolk, Oakland and Charleston. Automation of certain of the materials handling functions is also programmed for the naval supply centers at Long Beach, San Diego and Pearl Harbor and the naval supply depots at Puget Sound, Washington, at Guam in the Mariannas, at Subic Bay in the Philippines, and at Yokuska in Japan. The total cost of these systems will be a little over $6 million; however, based on studies the Bureau and the activities have conducted, the projected annual rate of savings will amount to $1.8 million. If all goes according to plan, the average amortization period is expected to be 3.3 years.[1]

Increased Productivity

The workload in warehouse operations is basically measured in terms of line items issued and received. One of the most representative ways of showing the real benefits of automation in materials handling is to compare the workload and the man years required to produce it before and after automation. Comparable

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[1] Program for Automated Materials Handling Systems AMHS, A report prepared by the Materials Handling Branch, Bureau of Supplies and Accounts, U. S. Navy Department, Washington, D. C., November 1, 1964, pp. 1-2.

data for Fiscal Years 1960 and 1964 are used for this purpose in the tabulation below.[1]

Activity	Before Automation, L/I Issued/ Recd (000)	FY 1960 Man Yrs.	After Automation, L/I Issued/ Recd (000)	FY 1964 Man Yrs.
NSC Bayonne	1,689	2,456	1,357	2,147
NSC Norfolk	4,135	5,136	4,185	4,522
NSC Oakland	3,500	5,206	3,142	4,542
NSC Charleston	736	852	1,375	1,243
NSC Philadelphia	415	1,087	949	1,227
	10,475	14,737	11,008	13,681

The above data show that the workload increased by 533,000 units from 1960 to 1964, representing a 5.1 percent increase. Total personnel man years required to produce this increased workload, however, declined by 7.2 percent in 1964, as compared to 1960. It cannot be concluded that automation of materials handling, in itself, accounted for all of the improved production rate. The figures shown were derived from the total line items issued and received at the activities. Some of the workload therefore represents bulk issues and receipts which are

[1]The data applicable to this tabulation were obtained from work measurement statistics compiled by the Systems Analysis and Procedures Division, Bureau of Supplies and Accounts, U. S. Navy Department, Washington, D. C.

not moved over the automated handling systems. Comparable data could not be obtained for the years 1960 and 1964 which would provide a before and after picture of workload and man years specifically applicable to the items moved over the automated handling systems. Some of the improved production rate, however, can be attributed to the automated handling systems.

The results of the Bin Consolidation and Popularity Storage Programs carried out in conjunction with the installation of the automated handling systems at each activity tend to obscure any figures developed to compute pure savings of the systems alone. These programs would have resulted in considerable savings in bin issue and receipt operations even without benefit of automation. The combination of these programs and automation, however, has provided an overall savings in bin issue operations that can be accurately derived. Since bin consolidation and popularity storage were prerequisites to the installation of the automated handling systems it is realistic to include these programs as a part of the total system and compute savings on this basis. The data shown below have been compiled using total supply system bin issues and therefore include bin issue operations of activities other than those having automated handling systems.

Bin Issue Operation Before Bin Consolidation and Automation

Fiscal Year	Line Item Issues (000)	Manhours (000)	Line Items per Manhour	Line Item Labor Cost	Pure Labor Cost ($000)
1959	12,000	1,280	9.64	23¢	3,200
1960	12,730	1,320	9.64	23¢	3,300
1961	14,256	1,479	9.64	23¢	3,697
1962	16,000	1,660	9.64	23¢	4,149

Bin Issue Operation After Bin Consolidation and Automation

Fiscal Year	Line Item Issues (000)	Manhours (000)	Line Items per Manhour	Line Item Labor Cost	Pure Labor Cost ($000)
1959	12,000	1,280	9.64	23¢	3,200
1960	12,730	1,128	11.29	22¢	2,818
1961	14,256	1,044	13.66	18¢	2,609
1962	16,000	960	16.66	15¢	2,400

The combined program savings that have resulted from bin consolidation, popularity storage and automation are computed from the above data as follows:

Fiscal Year	Savings
1960	$ 482,132
1961	1,088,075
1962	1,749,375
Cumulative Savings	$3,319,582

Line item issues per man hour for fiscal years 1963 through 1965 approximated those for 1962, therefore no additional significant savings accrued for these years.

Other Savings and Benefits

Increased productivity has been a natural adjunct of the automated handling systems. The savings that have resulted therefrom justify the systems and ensure their amortization within a reasonable period of time. There are other benefits besides increased productivity, but these are in areas in which savings or economies are more difficult to determine. One of these applies to the number of packs produced and the number of line items obtained for each pack. Transportation costs are based on both cube and weight for most modes of shipment. Any reduction in the number of packs to be shipped will thereby have an attendant effect on transportation costs. The accumulation features of the automated handling systems afford the opportunity for savings in this area.

Illustrative of the benefits that can be obtained in the packing area are the data developed by the Naval Supply Center, Norfolk in an evaluation study conducted of its system after one year of operation. For the year immediately preceding installation of the system the Center averaged 2.01 line items per pack from the retail bin issue area. After installation the Center was averaging

2.54 line items per pack which represents a 26.4 percent increase.[1] Stated another way this means the Center's packing requirements, i.e., number of packs, would have been 26.4 percent greater without benefit of automation. The Center was not able to determine what the actual dollar savings were as a result of the increased number of line items per pack; however, considerable savings must have resulted. More containers, cushioning materials, stencils and other packing related materials would have been required if the Center had not been able to increase the number of line items per pack. A greater number of packs would have also meant increased transportation expenses.

In the Norfolk study the Center also computed that automation in the bin areas had reduced its requirements for certain rolling equipment, such as fork lifts, tractors and pallet jacks. This equipment had previously been used to transport materials from the bin picking areas to packing stations. Annual savings of over $10,000 were estimated to be accruing from the elimination of the requirement for this equipment.[2]

To the tangible and measurable savings of the automated handling systems must be added intangibles which, while difficult to appraise and evaluate, are very real. Captain E. R. Sharp,

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[1]Cost-Savings Appraisal of Automated Conveyor Installation at NSC, Norfolk, A report prepared by the Material Department, U. S. Naval Supply Center, Norfolk, Virginia, December 31, 1961, pp. 6-7.

[2]*Ibid*., p. 4.

U. S. Navy, former Director of the Warehouse Operations Division, Bureau of Supplies and Accounts, in speaking on the subject of Navy automated handling systems at a recent joint industry-military materials handling conference stated:

> In addition to the sound financial character of the Navy investment, less tangible returns are realized:
> 1. Faster service to customers afloat and ashore.
> 2. A small inventory reduction due to less order lead time.
> 3. Flexibility ashore to adjusting rapidly to fluctuating work loads imposed by fleet operations.[1]

Speaking similarly about the expanded capability to provide improved service for the operating forces, Rear Admiral Lattu, Assistant Chief of the Bureau of Supplies and Accounts for Transportation and Facilities, appraised the merits of the Oakland system specifically and all the systems in general by this statement in a recent article:

> This system gives the supply center a capacity of 25,000 line items per shift and has tremendously increased its ability to provide better "Service to the Fleet." Collectively all six of these automated handling systems have given us the capability for handling a vastly increased volume of business not only for the fleet but for the other services and the civilian agencies as well.[2]

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[1]The National Security Industrial Association, <u>Proceedings Sixth Joint Industry-Military Packaging and Materials Handling Symposium</u>, Washington, D. C., February 25-28, 1962, p. 29.

[2]Onnie P. Lattu, "Integrated Materials Movement System," <u>Monthly Newsletter-Magazine of the U. S. Navy Supply Corps</u>, Vol. XXVII, No. 2 (February, 1964), p. 5.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The peace-keeping responsibilities of the Navy's far flung operating forces can only be effectively performed if the logistics support they require is properly and adequately provided. Realizing this, the Navy made major advances after World War II in automating many of the inventory control functions. These improvements enhanced supply support. Gains in this area pointed up the need for improvement in a related area--warehouse operations.

The mechanization and electronification of the materials handling element in the Navy's distribution system had tended to lag behind the paperwork element. While the handling and storage of bulk material had been accomplished more easily through palletizing techniques and utilization of fork lift trucks, little change in the handling of smaller items of material to fill end user requisitions had taken place. This had remained basically a manual operation. In addition, as the type of weapons needed for modern warfare had changed, more and different items of supply were required for proper logistics support. This had placed a heavy strain on an already overburdened warehousing system and had further complicated the basic job of "service to the fleet."

The Navy's objective in logistics support is optimum effectiveness in all phases of the supply distribution system. Warehousing operations are an integral part of this system. Mediocrity in this phase of logistics will tend to detract from effectiveness achieved in other phases. Warehousing effectiveness hinges on efficient handling of material. Efficient handling of material translates into better and faster service to customers and greater economy in the operation of the total supply system.

The growing volume of workload in warehouse operations together with the attendant costs involved motivated the Bureau of Supplies and Accounts in 1957 to seek improvements in this area, with automation as the logical step toward increased efficiency and savings. Consequently, feasibility studies were conducted, mechanized and semi-automated systems in use in the military and industry were examined, and available equipment was screened for possible application.

Research failed to reveal any practical method of automatically picking or selecting bin stocks, and it will probably continue to be a manual function for some time to come. The research revealed that a fully automated warehouse to handle the many thousand of different items stocked was an eventual possibility but its final attainment would probably extend far into the future.

The Bureau was unwilling to wait and decided automation could take over from the stock picking operation until the packing operation commenced. Research showed that all the intervening

materials handling functions--conveying, accumulating and sorting--could be automated. A concept of automation therefore evolved which we have today--automation from "pick to pack."

Considerable planning was required prior to installing an automated handling system at any of the activities. In order to accrue the maximum benefits of automation certain stock repositioning had to take place. Two storage improvement programs were already being carried out at some of the activities which were counterminous in nature with the type of storage arrangement required for an automated system. These were the bin consolidation and popularity storage programs. Under these programs stocks were repositioned by frequency of demand and all retail bin type material was consolidated in a single bin area. Concurrently with the implementation of these programs, studies were undertaken to analyze the frequency of customer demands. The findings disclosed that many customers serviced by the activities ordered five or more line items during a single day. This resulted in a provision for customer order accumulation to be designed into the systems.

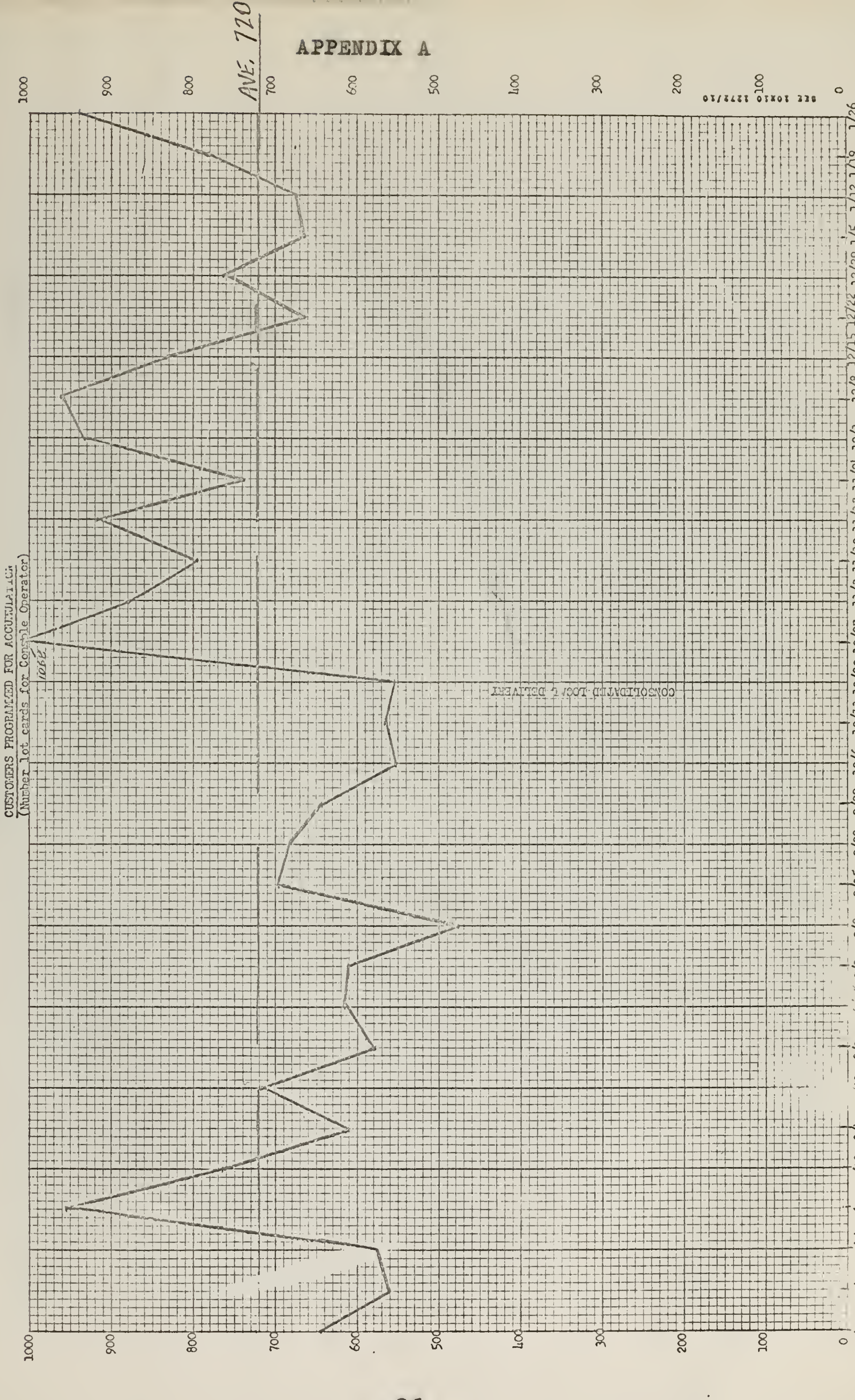
Using hardware and equipment that was currently available on the market, the Bureau designed and developed an automated system to handle retail bin issues. The Naval Supply Center at Bayonne, N. J. was chosen as the site for installation of the first system primarily because it had already created a storage environment that was the most compatible with system design.

Installation on the Bayonne system was completed in December, 1960, and operations commenced in January, 1961. Since then, additional systems have been designed and installed at four other major stock points. The systems basically feature a network of powered conveyors, automatic diverters, customer order accumulators and release mechanisms electrically operated from a controlling console to convey, accumulate and sort material from the point it is picked until it is delivered to packing stations. Since each supply activity has circumstances peculiar to itself, its automated handling system has been specifically engineered to meet its requirements.

Since installation of the first system at Bayonne, the Navy's total investment has amounted to $4 million. Expansion of present systems and automation of additional activities are expected to push total investment to about $10 million by 1970. The sound financial character of this investment speaks for itself. Actual and projected savings based on reduced personnel requirements alone permit the systems to be amortized in approximately a three-year period. Less definable savings are also being realized through reduced transportation costs and less expenditures for packing materials. Some of the more abstruse benefits being derived from the systems are improved issue processing time and expansion capability to handle increased workloads during emergency situations.

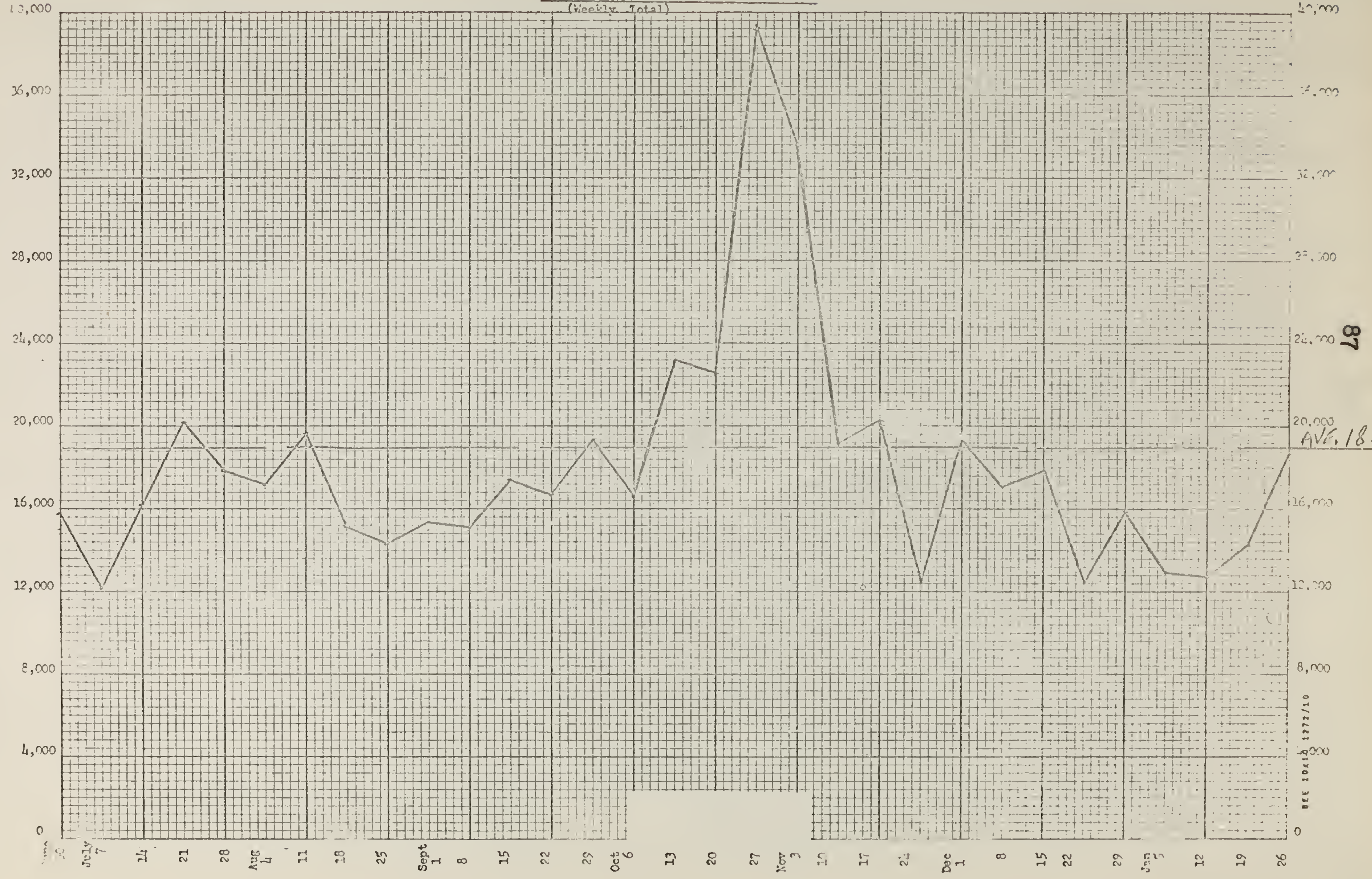
The speed and economy by which supplies can be moved through the physical distribution pipeline measures the effectiveness of a logistics system. Through warehouse automation the Navy has significantly improved the effectiveness of its logistics system.

APPENDIX A

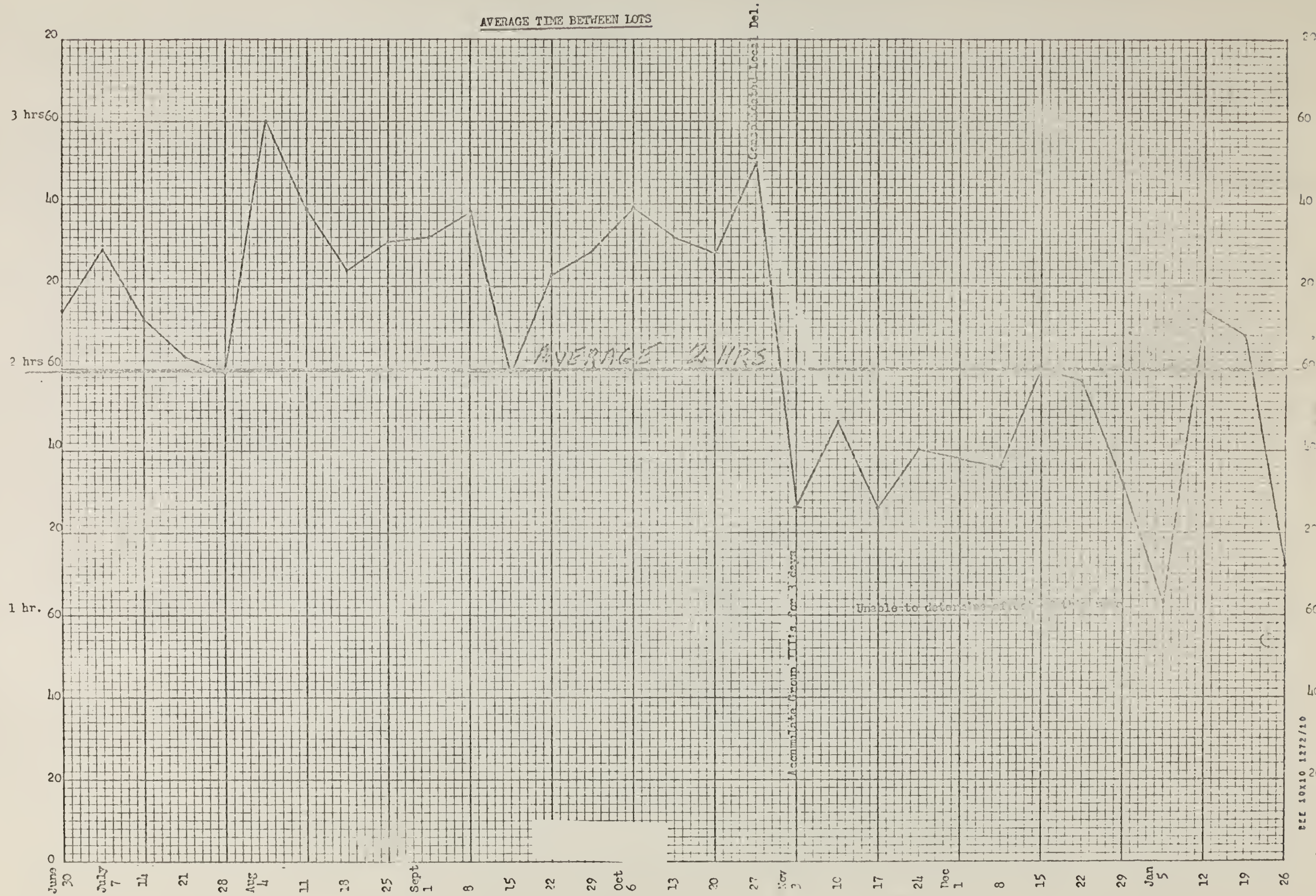

CUSTOMERS PROGRAMMED FOR ACCUMULATION
(Number lot cards for Console Operator)
AVE. 720
1068
CONSOLIDATED LOCAL DELIVERY

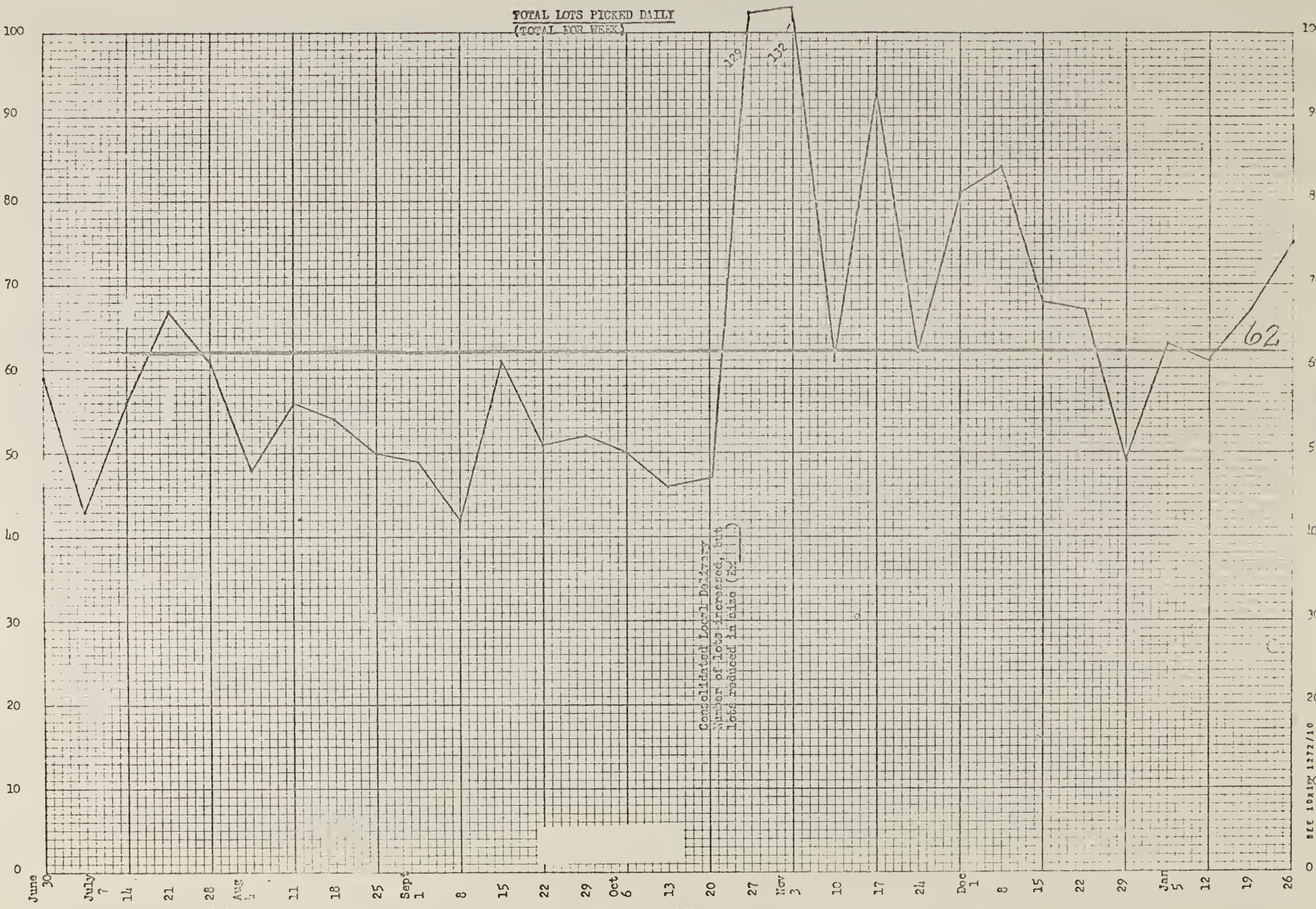
LINE ITEMS PROGRAMMED FOR ACCUMULATION

(Weekly Total)

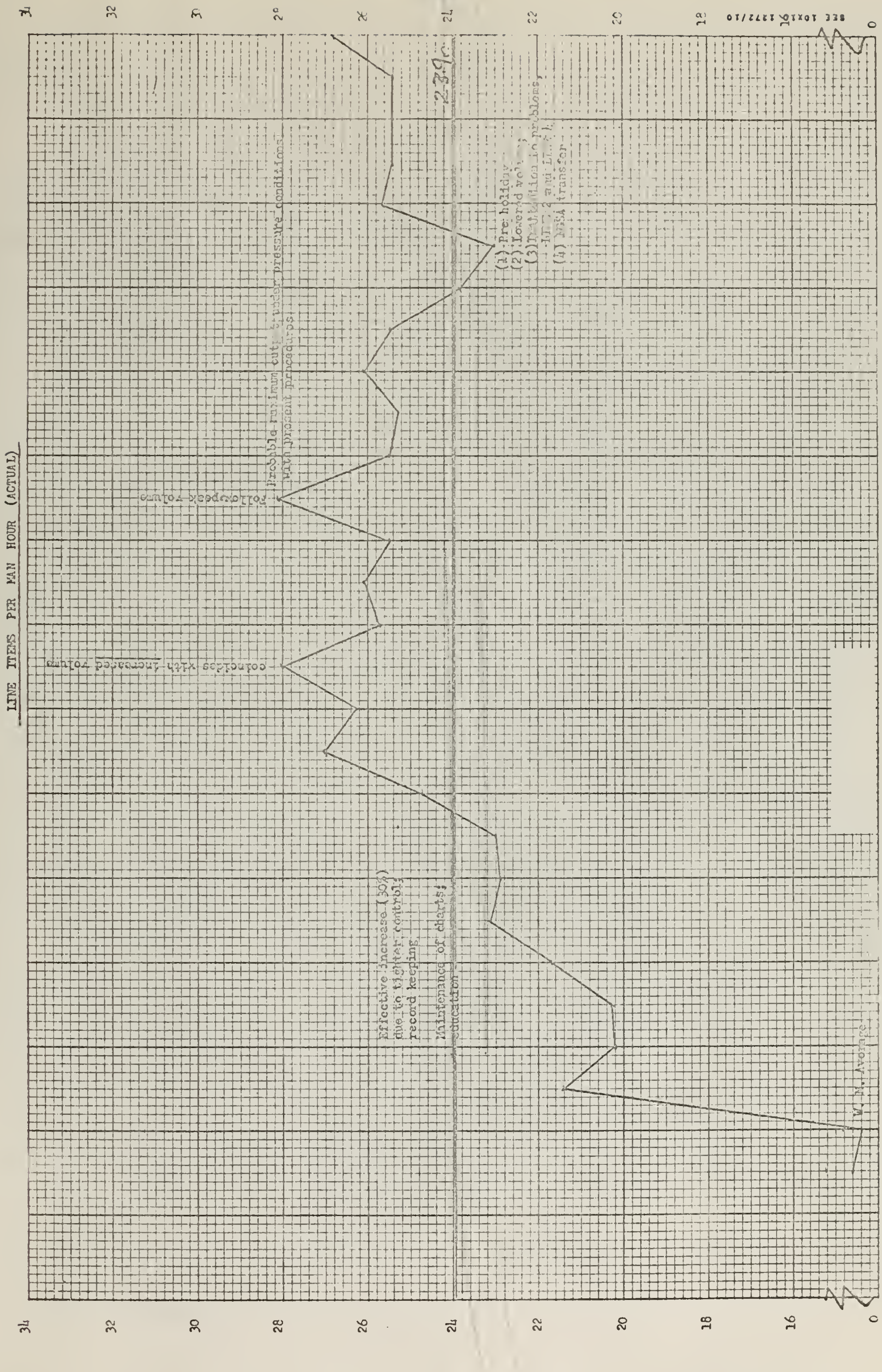


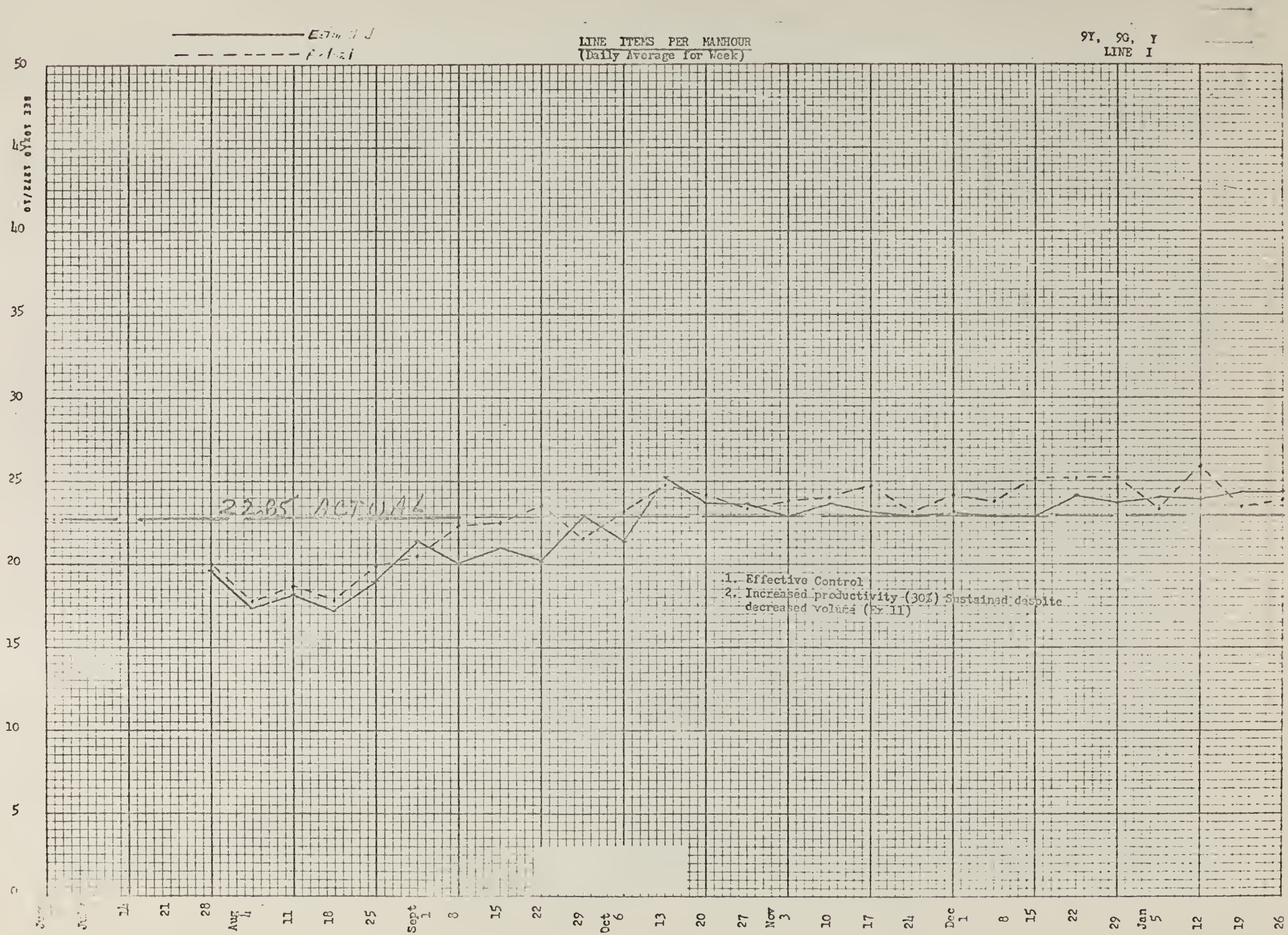
AVERAGE TIME BETWEEN LOTS





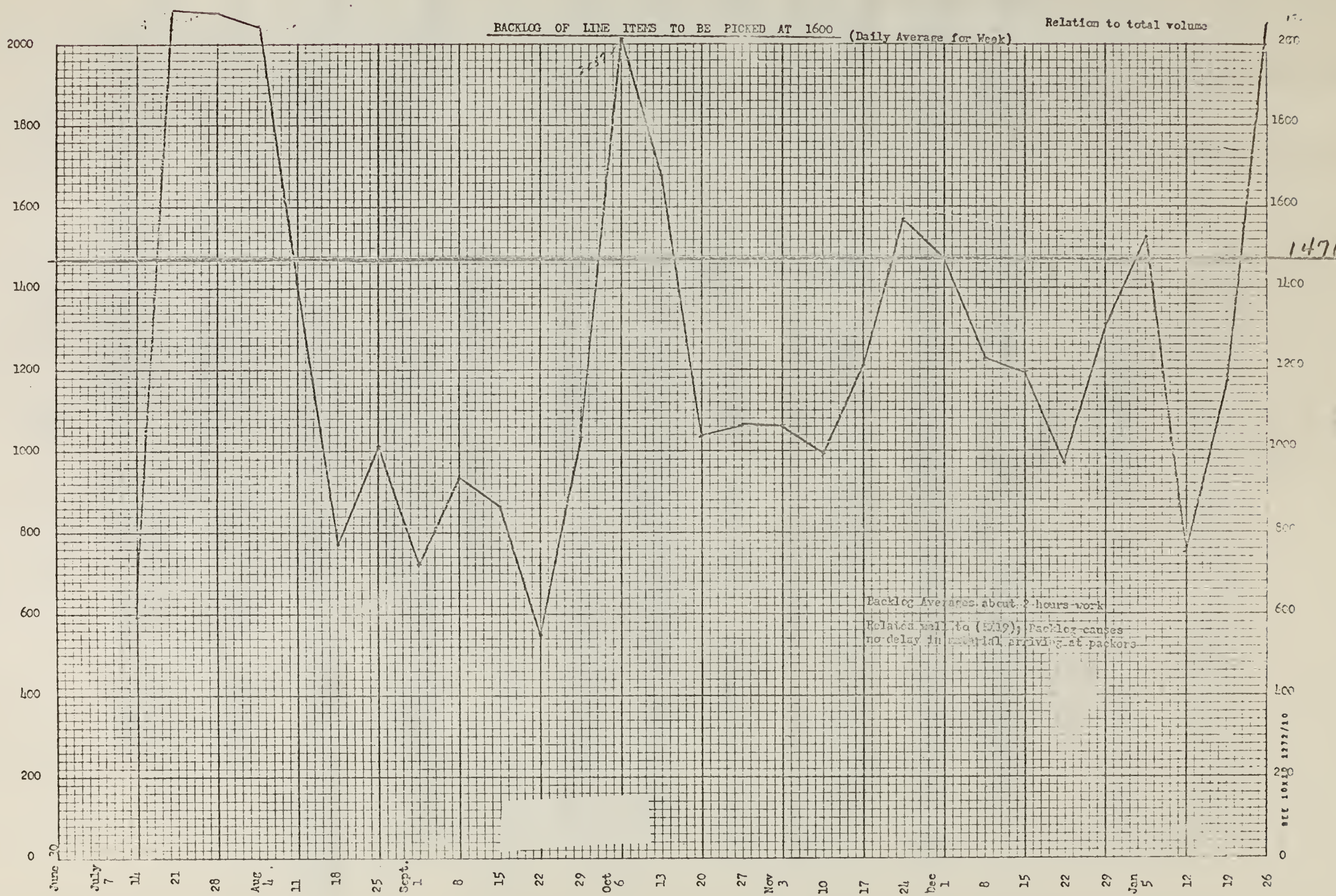
TOTAL LOTS PICKED DAILY
(TOTAL FOR WEEK)


LINE ITEMS PER MAN HOUR (ACTUAL)
coincides with increased volume
Follow peak volume
Probable maximum output under pressure conditions
With present procedures
Effective increase (30%)
due to tighter control;
record keeping
Maintenance of charts;
education
(1) Pre holiday
(2) Lowered vol
(3)
(4) transfer
W. M. Average
23.9
June 30
July 7
14
21
28
Aug 4
11
18
25
Sept 1
8
15
22
29
Oct 6
13
20
27
Nov 3
10
17
24
Dec 1
8
15
22
29
Jan 5
12
19
26
0
16
18
20
22
24
26
28
30
32
34


LINE ITEMS PER MANHOUR
(Daily Average for Week)
9Y, 9G, Y
LINE I
22.85 ACTUAL
1. Effective Control
2. Increased productivity (30%) Sustained despite
decreased volume (Ex 11)
50
45
40
35
30
25
20
15
10
5
0
14
21
28
Aug 4
11
18
25
Sept 1
8
15
22
29
Oct 6
13
20
27
Nov 3
10
17
24
Dec 1
8
15
22
29
Jan 5
12
19
26

BACKLOG OF LINE ITEMS TO BE PICKED AT 1600 (Daily Average for Week)

Relation to total volume



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